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SUMMARY OF THE FALL 1981 SPRINGING RESPONSE TRIALS AND HULL GIRDER CALIBRATION OF THE M/V STEWART J. CORT

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SUMMARY REPORT

JULY 1982

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16. Abstract

Continued full scale wave and stress measurements were conducted on a 1000 ft. Great Lakes ore carrier, the M/V STEWART J. CORT to increase the 1979 trials data base. The need for a larger data base was decided based on the limited agreement of results between the full scale data compiled from the 1979 trials and analytical predictions.

As part of the 1981 trials effort a hull girder calibration was performed which came within 10% of the expected results. A check of the calculated neutral axis showed very good agreement with the neutral axis location of the calibrated stresses. Limited funding prevented all of the data from being analyzed, except for the hull girder calibration which is presented. This report is therefore a summary of the 1981 springing response trials with descriptions of the changes made since the 1979 trials, the data runs taken, and a discussion of the hull girder calibration. No trials data, except for the hull girder calibration, is present.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Continued full scale wave and stress measurements were conducted on a 1000 ft Great Lakes ore carrier to increase the 1979 trials data base. The need for a larger data base was decided based on the limited agreement between the full scale results from the 1979 trials and analytical predictions.

Also as part of the 1981 trials effort a hull girder calibration was performed which came within 10% of the expected results. A check of the calculated neutral axis showed very good agreement with the neutral axis location of the calibrated stresses. Limited funding prevented all of the data from being analyzed, except for the hull girder calibration which is presented. This report is therefore a summary of the 1981 springing response trials with descriptions of the changes made since the 1979 trials, the data runs taken, and a discussion of the hull girder calibration. No trials data, except for the hull girder calibration, is presented.

ADMINISTRATIVE INFORMATION

The work described herein was performed by the Ship Structures Division at the David Taylor Naval Ship R&D Center (DTNSRDC) under funds provided by the U.S. Coast Guard MIPR-Z-70099-8-85117 under work unit 1730-603.

INTRODUCTION

This report is an account of the 1981 effort into the continued investigation of springing responses on the Great Lakes ore carrier M/V STEWART J. CORT. In the fall 1979, full scale trials were conducted on the CORT from which response amplitude operators (RAO's) were developed between midship stress and wave height measurements.[1*] These RAO's were compared with theoretical RAO's computed by the American Bureau of Shipping (ABS) and Webb Institute of Naval Architecture. These initial comparisons did not completely agree in some cases, indicating the need to more fully understand the structural response of Great Lakes ore carriers. The 1981 trials were intended to continue the measurement of midship stresses and wave height, and generate a larger data base of RAO's for comparison with the analytical predictions.

[1*] References are listed on page 17.

The overall objective of the research effort is to accurately predict springing and wave induced responses of ore carriers so that the longitudinal strength standards can be validated, to insure adequate longitudinal strength for longer (than 750 ft) ore carriers.

TEST OBJECTIVES

The original test objectives of the fall 1981 trials season of simultaneous wave and stress measurements were to:

1. Continue simultaneous full scale measurements of wave and stress during the 1981 fall shipping season.

2. Continue the data analysis and develop RAO's using the midship deck stress and the collins radar altimeter.

3. To complete the springing research on the CORT and to arrive at some specific conclusions concerning wave induced and springing stress combination.

As part of the approach to arrive at the above objectives, a static vertical calibration of the ships hull girder was to be performed at some time during the trials season. The results of this calibration were to be used to obtain a relationship between applied bending moment and stresses in the deck and keel, and to offer a check of the actual neutral axis against the calculated neutral axis and section moduli.

The test objectives were revised when funds remaining to complete the project became unavailable. As per sponsor request, simultaneous full scale measurements of wave and stress during the 1981 fall season were to continue and the static calibration of the hull girder would be performed, in lieu of generating RAO's between the midship stresses and measured wave height. The idea being that the data, once collected, could be analyzed at a later date when funds became available. The static hull girder calibration data was analyzed and the results are presented

in Appendix A of this report. Also included in the report is a summary of the trials preparation, full scale trials and the hull girder calibration. Information on the calibration of all tranducers used in these trials is given in Appendix B and a list of the header logs for each of the runs taken is presented in Appendix C. These header logs contain the ship conditions (speed, heading, location and draft) and the wind and wave conditions existing at the start of each run.

FALL 1981 FULL SCALE MEASUREMENTS

MEASUREMENTS AND INSTRUMENTATION

The 1981 fall trials were a continuation of the 1979 trials effort; the primary measurements being midship vertical bending stresses and wave height, both of which are used to calculate the RAO's. The same two wave height measuring systems used in the 1979 trials were used again during the 1981 trials. Both were configured and installed by the Naval Research Laboratory. The first, a Collins Radar Altimeter was mounted on a boom which extended about 4.5 meters off the ships bow. The second, a microwave radar unit was mounted on the port side on top of the pilot house.

As will be described later, the NRL microwave radar unit developed problems early in the trials and stopped functioning altogether, exhibiting continuous loss of signal. All wave height data is therefore based on the collins radar altimeter measurements.

A total list of transducer measurements is given in Table 1, and shown in Figures 1 through 3. The list includes midship stresses (main deck bottom and lateral bending and torsion), wave height, and corresponding vertical and horizontal accelerations of the wave height measuring units.

The major changes between the 1979 trials and 1981 trials, besides the static hull girder calibration are that, in 1981;

TABLE 1 - MEASUREMENTS FOR M/V S.J. CORT FULL SCALE TRIALS

1. MICRO-WAVE RADAR*
2. COLLINS RADAR*
3. BOW VERTICAL ACCELERATION (AT COLLINS)*
4. BOW HORIZONTAL ACCELERATION (AT COLLINS)*
5. BOW VERTICAL ACCELERATION (AT MICRO-WAVE)*
6. BOW HORIZONTAL ACCELERATION (AT MICRO-WAVE)*
7. MIDSHIP DECK VERTICAL BENDING STRESS (COMBINED)
8. MIDSHIP DECK VERTICAL BENDING STRESS (WAVE INDUCED)
9. MIDSHIP DECK VERTICAL BENDING STRESS (SPRINGING)
10. MIDSHIP BOTTOM VERTICAL BENDING STRESS (COMBINED)
11. MIDSHIP LATERAL BENDING STRESS
12. MIDSHIP TORSIONAL STRESS

* NRL INSTALLED MEASUREMENTS

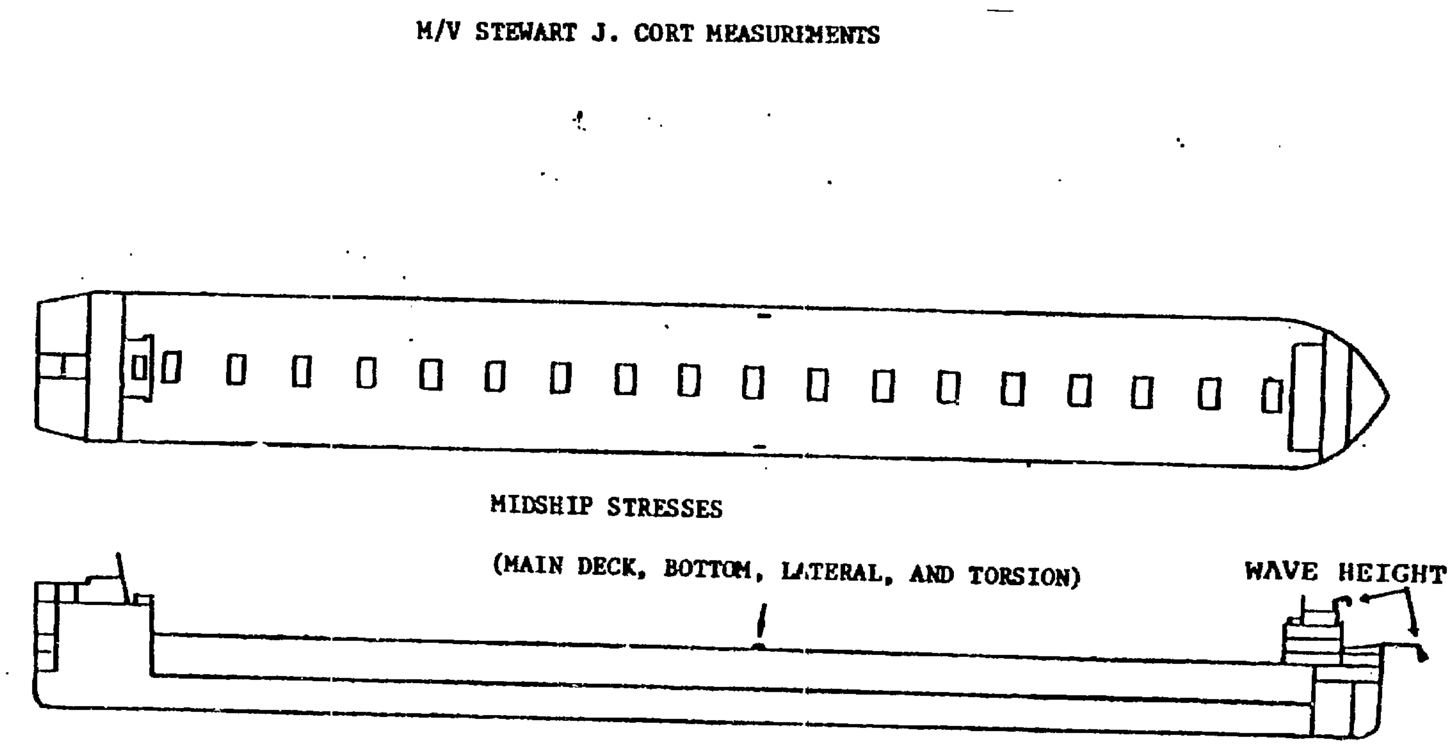
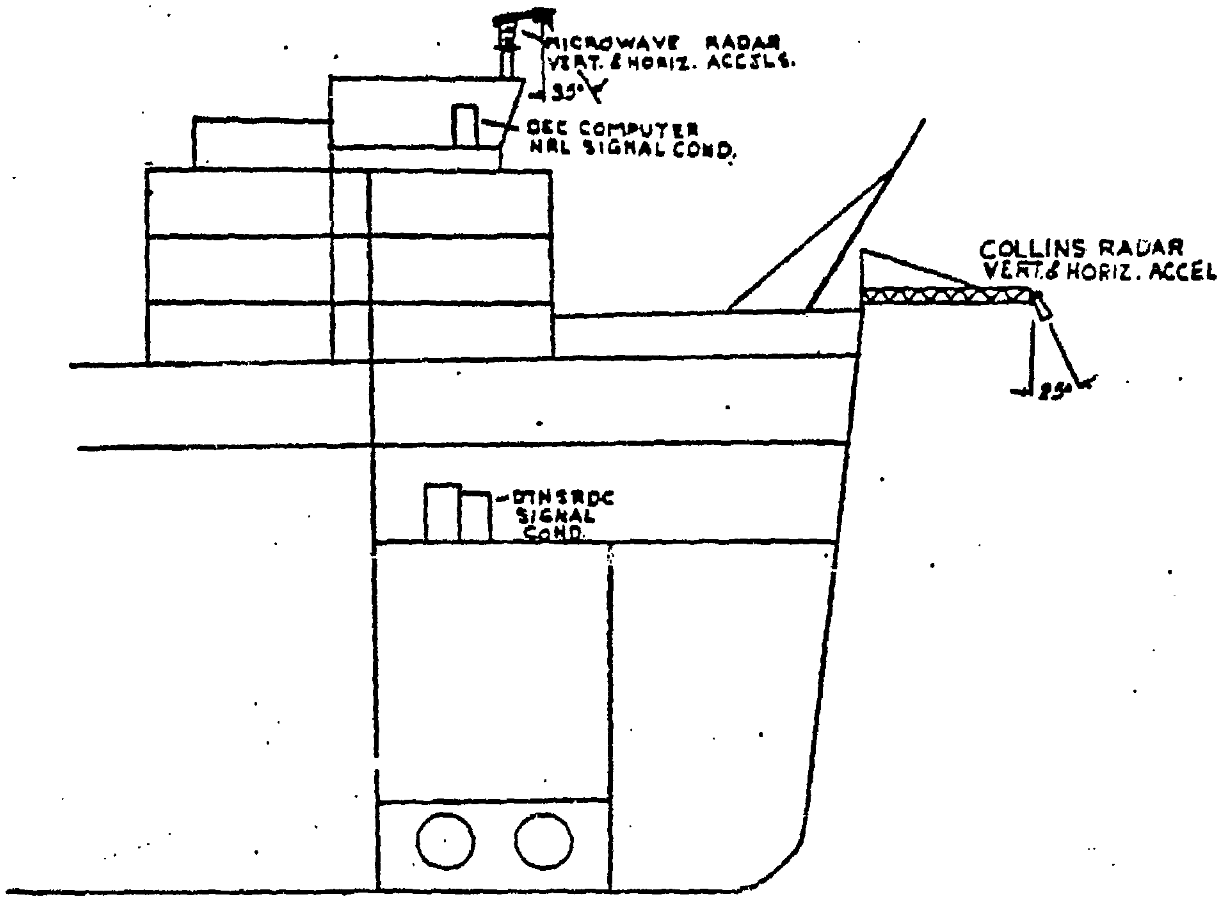


Figure 1 - Transducer Locations on the Ship



LOCATIONS FOR COMPUTER, SIGNAL CONDITIONING,
AND WAVE MEASURING SYSTEMS

Figure 2 - Forward Section with Wave Measuring Devices and Instrumentation

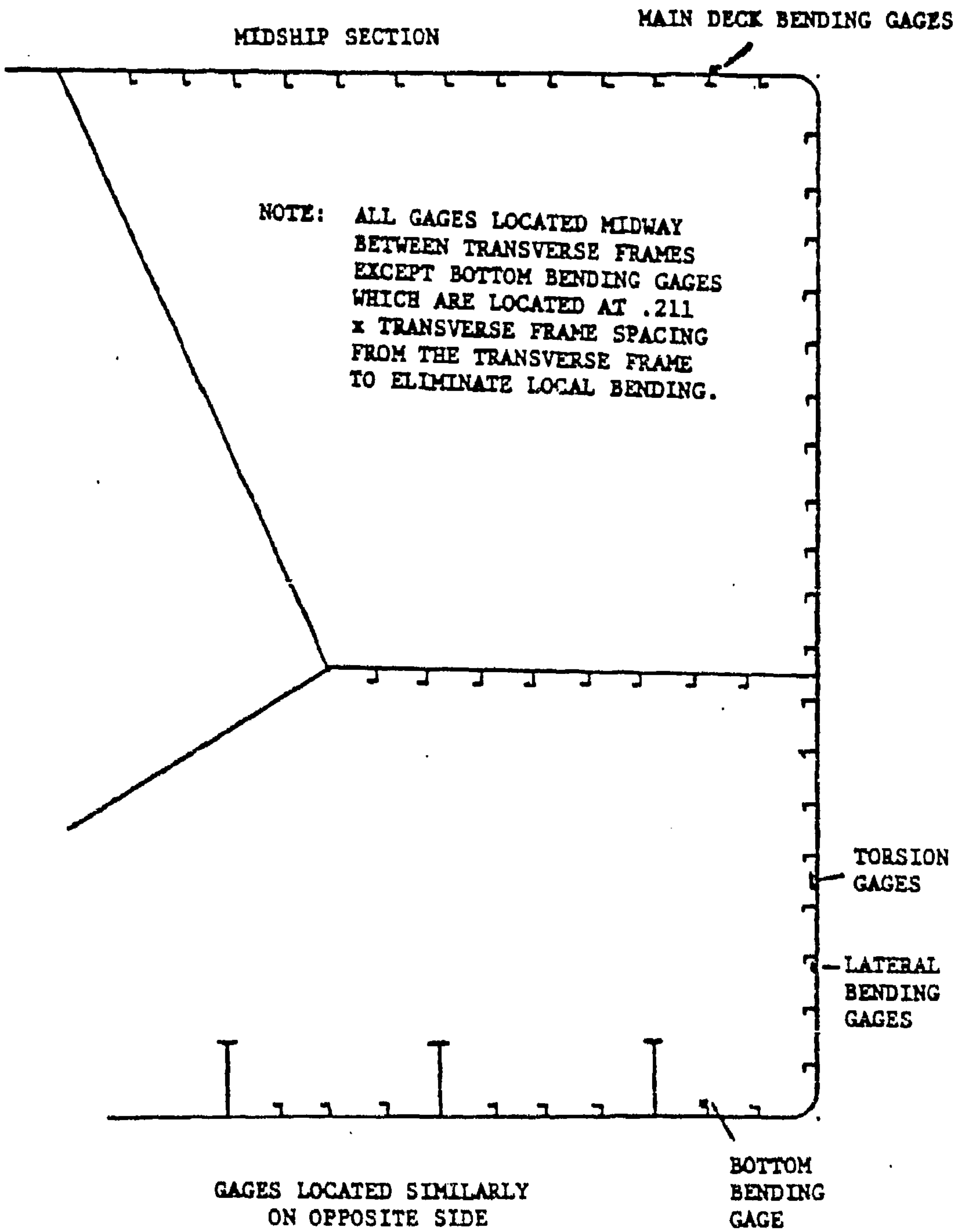


Figure 3 - Midship Strain Gage Locations

1. Full scale pressure measurements in the bow were not recorded. The pressure transducers were removed and replaced with plugs early in 1981 while the CORT was laid up for the winter.

2. Midship motions (pitch, roll, and heave) were not measured and,

3. Buoy wave height measurements were omitted, since the Collins radar altimeter and the microwave radar units were validated (using the 1979 trials buoy data and buoy data obtained again in 1980 by the Coast Guard see Reference 2) using helicopter deployed buoys.

A shakedown trial was conducted on the CORT during the summer of 1981 to reestablish the entire data collection and analysis system in preparation for the fall trials.

Problems with the keel strain gages (which had begun to drift toward the end of the 1979 trials season), and one of the main deck dyadic gages (which failed during the 1980 Coast Guard wave height correlation tests) dictated a partial reinstrumentation of the CORT prior to any data collection.

All main deck and keel strain gages located at midships were replaced, and duplicate gages were placed in the same vicinity and orientation as backups.

The main deck gages and spares were placed in a dyadic configuration approximately on foot forward of the gages used in the fall 1979 trials. The bottom bending gages and spares were placed on the top of the stiffener on the bottom plating, because of water lying on the plating surface. The bottom bending gages are in the same location as those used in the 1979 trials to eliminate local bending (i.e. 0.211 x transverse frame spacing).

The midship torsion and lateral bending strain gages, although not replaced, showed desired high resistance to ground and proper resistance through the gages themselves. The lateral bending gages are also laid out in a dyadic configuration.

All strain bridges, accelerometers, and wave height radar units were calibrated and functioning properly at the beginning of the 1981 trials (Appendix B gives details of transducer calibrations). The NRL microwave radar unit, when turned on, displayed the usual peaked oscilloscope display; although not specifically calibrated on board, it is assumed working properly when the peaked oscilloscope display is seen. Occasional signal drop-out occurred as the NRL microwave radar unit was tracking approximately 2 foot waves.

The PDP 11/03 computer, which was used to control the collection and storage of the digitized data on magnetic tape, was loaded on board at the end of the shake-down trials. At this time the computer was not fully operational in that it was unable to collect, new data but was able to reduce and analyze previously collected data. An attempt was made to identify and correct the computer problem before the fall trials began but the results did not confirm the computer would be operational by the start of the trials. As a precautionary measure, an analog tape recorder was brought on board and added to the instrumentation package at the start of the fall trials as backup to the digital tape system. The problems affecting the computer were identified and corrected during the first few days of the dedicated trials.

DATA COLLECTION

Over fifty data runs of 25 minute duration each were collected on board the CORT. The data collected consisted of roughly an even mixture of head and oblique sea headings. Most of the rougher weather was encountered in oblique sea conditions. On the last day of trials, however, when rough following seas prevented the ship from entering Burns Harbor, the Captain turned the ship around and headed back up Lake Michigan, allowing a series of head and bow sea runs to be recorded. Although the ship was traveling at a reduced speed, the waves were probably the highest and longest of any data runs collected during the 1979 and 1981 trials.

Most runs (Runs 1-40) were recorded on oscillograph traces to check for data consistency as well as being recorded on analog and digital tape. The remaining runs (41-57) were only recorded on digital tape and oscillograph traces.

The NRL microwave radar unit ceased functioning at the beginning of the trials and exhibited the same signal loss and dropout characteristics as it did during the 1979 trials. Daily attempts to bring the unit up and working failed, and subsequently no wave height data from the NRL microwave unit were collected. The horizontal accelerometer mounted on the NRL microwave unit began functioning unreliably after run #9.

The runs recorded on digital tape were digitized at 5 samples per second, (10 samples per second was used in 1979 to be compatable with the NRL microwave digital output signal, and then the data would be analyzed using every other data point to establish an effective digitizing rate of 5 samples per second).

Since the NRL microwave radar unit was not functioning properly, the digitizing rate was set at 5 samples per second, and every data point would be used in the data analysis, thus reducing the number of data points being handled and the amount of computer time required for data analysis. A sample rate of 5 samples per second still adequately defines the frequencies of interest for this vessel.

The Collins radar unit exhibited some drop out (loss of return radar signal), but these occurred very infrequently. The signal drop out is none-the-less compensated for in the software (if less than 2 seconds in duration) by linearly connecting the last data point before the dropout with the next data point after the dropout, and interpolating the missing data points before proceeding with the analysis. If the drop out is more than 2 seconds in duration the software prints a statement to that effect and stops the analysis.

A description of the data format used to store the data on the digital magnetic tape can be found in Appendix B of Reference 1.

STATIC CALIBRATION

As part of the fall 1981 full scale trials effort, a longitudinal hull girder bending moment calibration of the CORT was performed. During the 1981 season only one calibration was performed due to ship schedule. More than one would have been attempted had the opportunity to do so become available. The purpose of this calibration was to establish a relationship between a statically applied bending moment and the response of the main deck and bottom bending strain gages. In this way, induced bending moments can be derived from strains measured during the fall 1981 shipping season. The results of this calibration were also used as a check against the calculated neutral axis and section moduli.

The calibration was performed by selectively changing ballast in the seven middle ballast tanks as outlined in Reference 3. With minimal interference to the ships schedule, the calibration was performed dockside at Burns Harbor with the ship initially in the code 1 ballast condition ready for departure.

The whole calibration took approximately 3 hours, starting at 1730 hours with the initial code 1 ballast condition, to the specified calibration ballast condition and then back again to the code 1 ballast condition.

Through the two step calibration, the main deck, bottom bending and torsional strain bridges were monitored, in addition to the draft meters (forward, amidships, and aft), temperature (deck, air, and water) and athwartship trim lights located on the engine room deckhouse. The torsion bridge output and the trim lights indicated the second step was not fully complete as the ship was preparing for departure, and was therefore not used in the calculations.

The weather conditions during the calibration were overcast during the day with drizzling rain beginning in the late afternoon and continuing through the night. The main deck and keel (water) temperatures (38° and 44° Fahrenheit respectively) remained constant during the calibration, with the air temperature fluctuating only one degree Fahrenheit (37° to 36°). Since the main deck and water temperatures remained constant during the calibration, any effect of diurnal stresses on the calibration was assumed to be negligible.

The ballast level in each ballast tank was checked by looking down the scuttle hatch at the top of the tank and counting down the number of ladder rungs to the ballast surface. The rungs are spaced one foot apart, the first rung being one foot off the bottom of the tank, and the top rung being twenty seven feet off the bottom.

When the ballast in each of the tanks was at the specified level, the lines holding the ship to the dock were slacked so that the friction between the ship and dock would not interfere with the calibration. Voltage outputs from the main deck bending, bottom bending and torsion bridges were then monitored at the signal conditioning in the forward machinery room, the terminal strip on the back of the computer, and were recorded on digital tape. All three voltage readings were consistent, at each step of the calibration. Shunt calibrations of the strain gage circuits were also performed at each of the calibration steps to insure the signal conditioning, amplifiers, etc. were working properly.

The ship was not intended to trim or change draft, but the change in draft readings indicated by the ships draft gages, showed that it did set slightly deeper in the water and trimmed slightly by the bow, comparing the change from the initial code 1 ballast condition to the calibration ballast condition. Drafts were initially 12'6" FWD, 16'3" AMID, 20'6" AFT and changed to 12'7 1/2" FWD, 16'8 1/2" AMID and 20'3" aft at the calibration ballast condition. Some change in draft readings is

attributable to bending of the hull due to the induced loading, as will be discussed later, as well as the combined effects of the free water surface of the ballast and the accuracy to which the ballast can be loaded to the nominal specified depth. The remaining changes are felt to be errors in the draft gage readings themselves, as will be discussed later in Appendix A. The effects of these changes were taken into account in the calculations and plots given in Appendix A.

The bending moment, based on the nominal change in ballast, draft and trim was found to be bounded between 235,100 and 198,000 Ft-Ltons (SAG) at the gage locations.

Based on the voltage outputs from the main deck and keel bending strain bridges, the gages read stresses of 5.125 ksi compression in the deck plating and 4.437 ksi tension on top of the bottom plating stiffener, corresponding to an average bending moment of 217,836 Ft-Ltons (SAG).

Comparing the average bending moment obtained from the strain gage outputs with the actual applied bending moment limits based on the nominal ballast changes and corrected for any draft and trim charges, the actual comes within 10% of that seen by the main deck and bottom bending strain gages.

The neutral axis location was calculated to be 23.01 ft above the baseline, and based on the recorded stresses during the calibration, was found to be located 23.10 feet above the baseline; a very good comparison.

It should be kept in mind that the above calculations relating stress at a point on the cross section of the ship with the bending moment acting on that cross section assumed a uniform stress distribution along the width of the ship, with little or no lateral restraint.

The effects of a non-uniform stress distribution (shear lag effect) would produce slightly higher than nominal stresses near the edges of the ship (where the strain gages are located) and near the edges of the cargo hatches due to the

longitudinal bulkheads, with slightly lower than nominal stresses occurring at the mid points. The material between the hatches is assumed to be ineffective in carrying load. The actual shape and magnitude of the stress distribution across the width of the ship with respect to the nominal stress is not known, but could be determined from a simple finite element model.

The effects of mill tolerances, which on the average produces plating and scantlings slightly above the nominal dimensions, can slightly reduce measured responses below the nominal calculated values.

Some error was undoubtably introduced in ballasting the tanks to the nominal specified levels, due not only to the difficulty of sighting the water level down inside the tanks, but also the effect of the size of the tanks (large surface area) has on the ballast weight based on the depth readings.

Another factor to be considered in the comparison would be electronic drift of the instrumentation when readings are taken with respect to the same initial reference over a long period of time.

SUMMARY AND RECOMMENDATIONS

Dedicated fall trials have been completed for the 1981 shipping season. Over fifty data runs of 25 minute duration each were collected on board the CORT. The data collected contains roughly an even mixture of head, bow and oblique sea headings. Most of the rougher weather was encountered in oblique seas, except for a series of head and bow sea runs obtained on the last leg of trials in very rough seas. Most of the data remains to be analyzed due a change in project objectives and available funding.

As part of the fall 1981 trials effort, a longitudinal hull girder bending moment calibration of the CORT was performed by recording hull strains while making

known changes in the ship's ballast condition. The actual bending moment, after being corrected for changes in the buoyancy distribution caused by the deflected shape and slight draft and trim changes, agreed to within 10% of the average seen by the main deck and bottom bending strain gages.

The correction due to the buoyancy distribution was found to be between 15.5% and 28.8% of the uncorrected bending moment distribution. The measured stresses show this correction to be 21.7%.

Possible explanations for the 10% disagreement include the effect of shear lag in the plating, which sheds load from the unsupported sections of the plate to the edges which are supported by longitudinal bulkheads, effectively increasing the stresses in those areas; mill tolerances of plating and scantlings which can be slightly above nominal; error introduced from the draft gage readings; error introduced in ballasting the tanks to specified levels due to the large size of the tanks and the difficulties in sighting the depth from the scuttle hatch at the top of the tank; and errors inherent in any electronic signal conditioning when readings are taken with respect to the same initial reference over a long period of time.

A comparison of the calculated neutral axis location, 23.01 feet above the base line and the neutral axis location determined experimentally during the hull girder calibration, 23.10 feet above the base line shows very good agreement.

To establish some definite conclusions about springing and wave induced stresses, (their combination to produce a maximum, consistency of the theoretical and measured RAO's, assymetry of the measured main deck and bottom bending time history data[4,5]), a concerted effort is recommended to reduce and analyze the remaining data collected during the 1981 trials, and along with the data collected during the 1979 trials, be compared and collectively analyzed.

Included in this effort, in addition to developing RAO's, histograms of the vertical bending channels (main deck combined, wave induced, springing, and bottom bending) should be analyzed to determine their actual distribution, which is important when maximum expected values are determined from the area under the response spectra.

A brief analysis of some of the data collected early in the 1981 trials suggests the distribution of the data is not quite a Rayleigh distribution as was initially assumed, but rather a more general Weibull distribution, (of which a Rayleigh distribution is a specific form).

At the end of the 1981 trials season, all instrumentation and equipment associated with these trials was removed, and the CORT was restored to pre-trials condition. The digital data tapes will be available at DTNSRDC for future analysis.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to the following individuals for their support in this trials effort.

Mr. David Walden who was the technical representative for the Coast Guard. The Bethlehem Steel Corporation for the use of the M/V S.J. CORT for these trials, and Mr. Charles Walburn of the Marine Division of Bethlehem Steel for arranging the schedule of operations aboard the CORT. Captain Robert Brabander, master of the CORT, and the crew for their cooperation and willingness to help throughout the trials season. Mr. John C. Davies III of the DTNSRDC Central Instrumentation Department for his help with the data acquisition and analysis software. Messrs. Mr. William Hay and Frederick Palmer for assisting in the instrumentation setup, data collection, and support. Mr. Alfred L. Dinsenbacher who provided guidance and suggestions throughout the project.

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APPENDIX A
STATIC CALIBRATION CALCULATIONS

The bending moment produced from the change in ballast loading has to be corrected to account for the change in buoyancy distribution reacting any change in trim, draft or deflected shape. This net bending moment, the bending moment due to the change in ballast minus the bending moment due to the change in buoyancy distribution, is the actual bending moment being applied to the ship.

Although the ship was not intended to trim or change draft, the draft readings indicated that it did set slightly deeper in the water and trim slightly by the bow. Slight changes car attributed to the bending of the hull due to the induced loading as well as the combined effect of the free water surface in the ballast tank and the accuracy to which the ballast can be loaded to the nominal specified depth, and are accounted for in the calculations. The draft readings themselves are also felt to be slightly in error, as will be discussed later. Overall trim, i.e. nominally 8 ft by the stern, appears to be correct.

The calculations are based on the initial assumption that the draft meters were reading the draft accurately. The draft meters are located 447.92' fwd ℄ ,33.67' fwd ℄ and 425.25' aft ℄ ; and initially read 12'6" fwd, 16'3" amid, 20'6" aft and changed to 12' 7 1/2" fwd, 16'8 1/2" amid, and 20'3" aft at the calibration ballast condition.

The overall trim of the CORT, in the initial ballast condition, indicated by the fore and aft draft gages was 8 ft by the stern, which gives a ballast depth differential of 0.88 ft inside each ballast tank, the ballast level at the aft end of the tank being 0.88 ft deeper than the forward end.

The overall trim of the CORT, in the calibration ballast condition, was 7' 7 1/2" by the stern, which gave a ballast depth differential of .84 ft inside each ballast tank. Taking the specified depth at the ladder (located 10 1/2 feet from

the aft end of the tank) to be the nominal depth of ballast in the tank, see Table A1, the ballast depth at the fore and aft ends of each tank could be determined, and an average weight of ballast calculated for each tank at the initial and calibration ballast conditions. The difference between the two conditions is the nominal calibration loading, which is nearly 300 Ltons of excess weight, the calibration condition being heavier than the initial condition. By integrating the change in load diagram once, the shear force diagram is developed. Integrating once again, the bending moment diagram due to the change in ballast loading is developed. For the sake of comparison, the bending moment diagram due only to the change in ballast loading is shown in Figure A1. This is not the only bending moment that is acting on the ship. There is a reaction due to the change in buoyancy distribution corresponding to the deflected shape, and change in trim and draft of the ship.

Using the bending moment due only to the change in loading as a starting point, an approximate deflected shape was obtained by integrating the bending moment distribution twice; the stiffness EI, was assumed to be constant along the length of the ship. The deflection curve thus obtained was forced to fit through the three changes in draft readings and indicates the change in draft along the length of the ship, which was used to obtain a change in buoyancy diagram.

The ship was divided up into twenty stations of fifty foot lengths, and the average buoyancy force was calculated at the midpoint of each station. By adding the load diagram due to the change in ballast loading (sag amidships) to the load diagram due to the buoyancy reaction of the loading (hog amidships) the first iteration to the actual load acting on the ship was obtained. Integrating the change in load diagram once gave the shear force diagram, and integrating twice gave the bending moment diagram due to the combined buoyancy reaction and change in the ballast loading acting on the ship.

This new bending moment diagram was then integrated twice to obtain a new deflected shape, which in turn was used to obtain a new change in buoyancy distribution. When added to the load diagram due to the change in ballast loading, new shear and moment diagrams due to the combined load distribution were obtained. Each cycle of the iteration gave a slightly better estimate of the deflected shape. The deflection diagram due to the combined load distribution were found to be quite insensitive to each successive iteration; converging to nearly the same values after each iteration. Each time there was found to be about 600 Ltons of excess buoyancy at an LCG of about 170 ft FWD ⊠ . The amount of excess weight from the free surface effect of the ballast loading, about 300 Ltons, at a LCG of about 11 ft FWD ⊠ had already been accounted for. The remaining 300 Ltons, difference (less than 4 % of the total ballast change), was considered to be partially the effect of the actual ballast depth with respect to the specified nominal ballast depths, the accuracy to which the ballast can be added to the tanks and partially the effect of the nominal draft readings.

It seems most likely, from the discrepancy in the LCG locations of the change in ballast and resulting buoyancy distributions, that most of the error is due to the draft readings (particularly the forward reading) since the LCG of the buoyancy distribution disagrees the most from the nominal expected values.

Further, for example, even if the actual ballast depths were off by as much as 1 1/2 inches from the specified levels in the tanks, in both the initial and final condition, in such a way as to shift the LCG of the ballast forward toward the LCG of the buoyancy reaction, the ballast weight only increases to 393.4 Ltons and the LCG of the ballast moves to 55.36 ft FWD ⊠ .

A solution was therefore obtained by bounding the problem within upper and lower limits. A lower limit was obtained by using the measured draft readings,

even though were felt to they contain some error, and using the above specified changes in ballast (corrected for the free surface affect) conservatively assuming them to be off by as much as 1 1/2 inches, so that the LCG of the ballast would be closer to that of the buoyancy distribution. The moment diagram was forced to close, effectively forcing equilibrium. Even this conservative lower limit (198,000 Ft-Lton at the gage location) is within 10% of the measured value. See Figure A1 for bending moment distribution. It should be noted that as the LCG's of the ballast and buoyancy distributions approach each other, the bending moment diagram approaches the measured value.

An upper limit was obtained by calculating a reactive buoyancy distribution to match the change in ballast distribution (corrected for the free surface effect) and using these distributions to obtain a moment diagram. The first estimate of the buoyancy distribution was obtained by substituting the measured stresses into equations 1 and 2 of reference 6 which relate midship stress in terms of midpoint to bow or stern deflection, averaging the results and scaling the previous deflected shape. Subsequent deflections were obtained by integrating the shear and bending moment diagram (see reference 7 for details) of the combined ballast and buoyancy loadings to obtain a consistent midpoint to bow or stern deflection. The resulting deflected shape was then positioned using the TPI and MTI obtained from the ships hydrostatic plans for a mean draft of 16'6" (TPI=224.5 Ltons/in and MTI=16,150 Ft-Ltons/in) to achieve equilibrium between the change in ballast loads and the change in buoyancy reaction. This upper limit (235,100 Ft-Ltons at the gage location) is within 8% of the measured value. See Figure A1 for the upper limit bending moment distribution.

BENDING MOMENT CALCULATIONS FROM STRAIN GAGE READINGS

Changes in stress were monitored from the main deck and bottom bending strain gages as the ballast in the middle seven ballast tanks was changed from the initial

code 1 ballast condition to the calibration ballast condition (the torsion gages were also monitored but had a negligible change in output voltage, as expected).

A change in stress of 5.125 ksi compression and 4.437 ksi tension were recorded from the main deck and bottom bending strain gages respectively. The deck gages were located on top of the deck plating and the bottom gages were located on top of the stiffener on the bottom plating (.67 feet above the outside bottom plating). The section properties given in Reference 2 were recalculated with greater accuracy and are given in Table A2. Based on the recalculated section properties of the midship cross section, these changes in stress can be converted to a bending moment. Assuming the stress distribution along the width of the ship to be uniform when a vertical bending moment is applied, the vertical bending moment based on the recorded changes in stress were found to be 217,055 Ft-Ltons and 218,619 Ft-Ltons for the deck and bottom bending gages respectively. The average vertical bending moment based on the output from the strain gages is therefore 217,835 ft-Ltons (sag).

Comparing the actual vertical bending moment calculated from the nominal ballast loading and draft readings with that obtained from the strain gage outputs, the actual bending moments come within 10% of the bending moment obtained from the strain gage outputs.

As a comparison of the upper and lower limit curves, and the measured bending moment shown between them on Figure A1, it is seen that the upper limit curve employs a 15.5% correction, due to buoyancy, of the uncorrected bending moment curves shown in Figure A1; the lower limit curve, a 28.8% correction; and the measured bending moment, between the two limits, a 21.7% correction due to the change in buoyancy distribution which is a combination of deflection, sinkage and trim.

As a check on the calculated neutral axis (calculated to be 23.01 ft above the outside bottom plating, or baseline) the stresses recorded during the calibration were used to determine the measured neutral axis location. With a compressive stress of 5.125 ksi located 49 feet above the baseline and a tensile stress of 4.437 ksi located 0.67 feet above the baseline, the location of zero stress or the neutral axis is found to be 23.10 feet above the baseline, which agrees fairly well with the calculated neutral axis location.

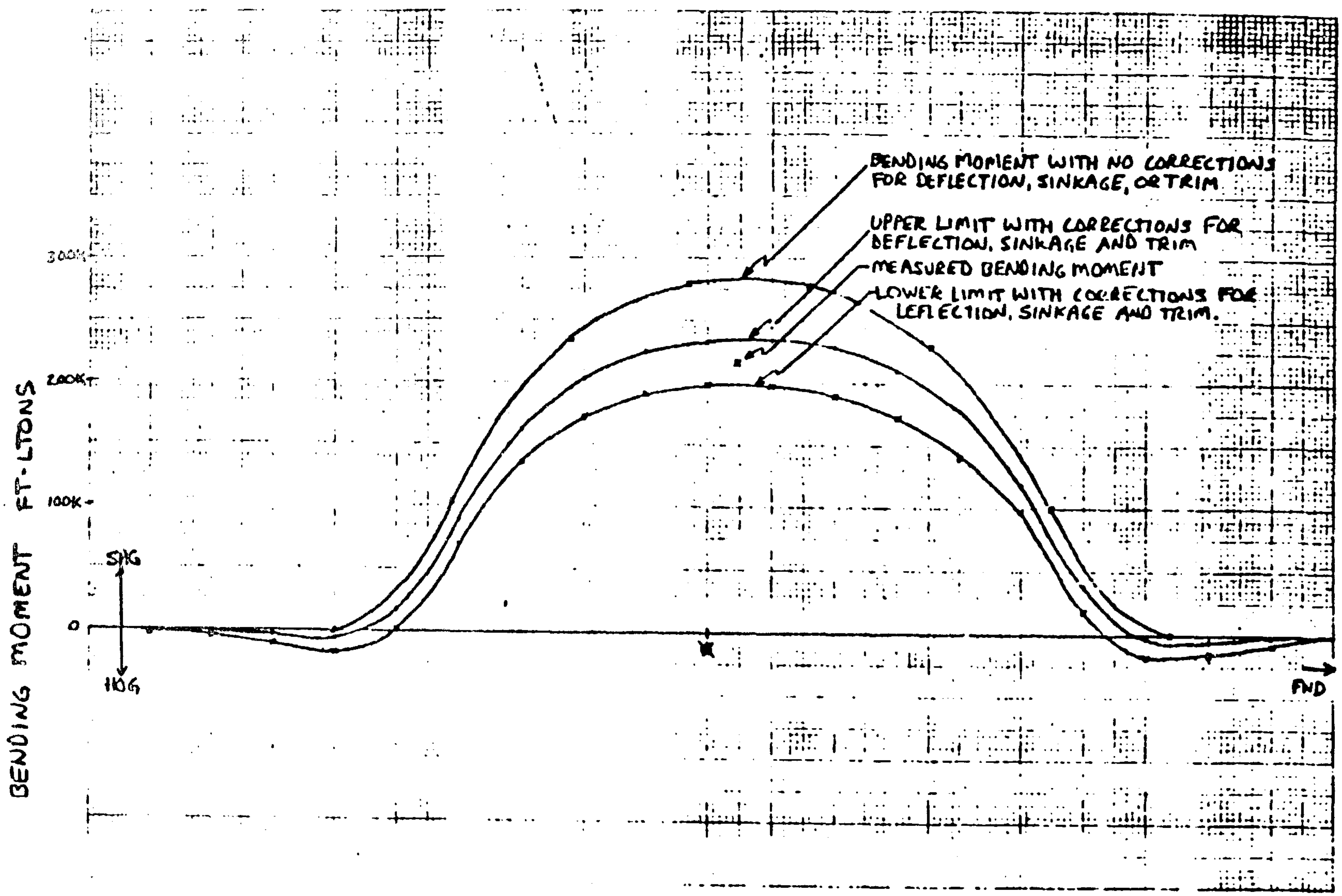


Figure A1 - Actual Bending Moment Diagrams With and Without Buoyancy Corrections For Deflection, Sinkage, and Trim

TABLE A1 - SOUNDING DEPTHS OF TANK BALLAST BEFORE AND DURING CALIBRATION

TANK	SOUNDING (FT) (SHIP IN BALLAST CODE 1)	SOUNDING (FT) (DURING CALIBRAITON)
1	16	16
2	14	1
3	15	22
4	25	FULL
5	26	FULL
6	25	FULL
7	21	FULL
8	21	9.5
9	21	21

TABLE A2 - INERTIAL PROPERTIES AT CORT MIDSHIP SECTION*

MOMENT OF INERTIA ABOUT N.A.	2465640 IN^2FT^2
DISTANCE FROM N.A. TO DECK	25.99 FT
DISTANCE FROM N.A. TO KEEL	23.01 FT
SECTION MODULUS DECK	94832 IN^2FT
SECTION MODULUS KEEL	107202 IN^2FT

* Calculations are based on scantling dimensions shown on Erie Marine Inc. Drawing #101-S11-11-6 "Midship Section Final."

APPENDIX B
TRANSDUCER CALIBRATIONS AND SENSITIVITIES

The measurements listed in Table 1 of the text consist of stress, wave height and acceleration, each of which were calibrated periodically to check their sensitivities, the ratio of engineering units to output voltage, and insure they were operating properly.

The four strain bridge channels (main deck, bottom and lateral bending and torsion) were electrically calibrated with shunt resistors. Each of the strain gages were wired up in a Wheatstone Bridge circuit with active strain gages and dummy resistors as shown in Figures B1, B2, B3 and B4. The main deck and lateral bending gages were mounted in 2 dyadic configuration on the hull plating; the torsion, at 45° to the vertical and the bottom bending gages, longitudinally on the top of the bottom plating stiffener at the local bending inflection points.

The calibrations were performed by placing shunt resistors in parallel with the strain gages to simulate a compressive strain in that arm of the bridge. These shunt calibrations were performed at the gage site initially to obtain the true sensitivity and daily thereafter at the instrumentation site in the forward machinery room. The output voltages compared well with the calculated values, indicating the signal conditioning and amplifiers were all working properly. The transducer output voltages for the strain gages based on shunt calibrations at the gage site are also included in Figures B1 through B4.

The main deck bending signal was filtered into its wave induced and springing components to assess the relative magnitudes of the stresses as an aid in determining when to take data runs. The wave induced component was produced by low pass filtering the main deck bending signal with a cutoff frequency of 0.2 Hz, and the springing component by high pass filtering the main deck bending signal with a cutoff frequency of 0.25 Hz. Each of the two filtered channels employed two

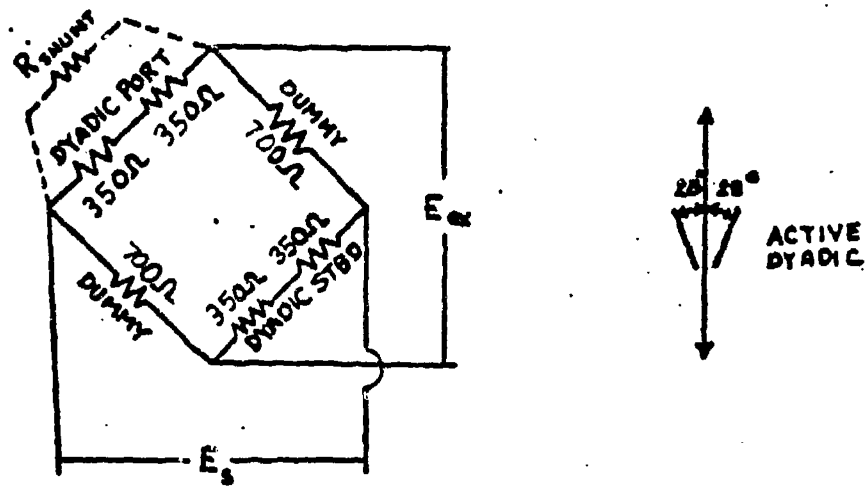
48 db/octave Khronhite variable filters, which were cascaded to provide a 96 db/octave rolloff. The filter characteristics, phase lag and attenuation as a function of normalized frequency with respect to cutoff frequency, were calibrated at DTNSRDC with a function generator and frequency counter and are given in Figures B5 and B6. Each of the four strain channels were initially filtered at the signal conditioning using low pass 2 pole Butterworth filters with a 12 db/octave rolloff and a cutoff frequency of 10 Hz.

ACCELEROMETERS

The vertical and horizontal accelerometers mounted on each of the wave measuring units were installed by NRL with the sensitivities given in Table B1. The transducers were periodically calibrated (in port with calm conditions) by tilting them at various angles to simulate fractions of gravitational acceleration and measuring the output voltage to assure that they were still functioning as calibrated in the NRL lab. The accelerometer signals were filtered at 4 Hz at the NRL instrumentation using a 4-pole Bessel filter.

COLLINS ALTIMETER

The Collins Radar Altimeter was calibrated, to insure it was functioning properly, when the ship was in port, and in calm water. The antenna horns, which were angled outward at 25° from the vertical during data runs, were angled down vertically for the calibrations. The calibration consisted of monitoring the change in output voltage as the horns, attached to the boom, were swung out over the water and clear of the ship, and then back again over the deck. The sensitivity was checked by dividing this change in distance by the change in output voltage as shown in Figure B7.



SHUNT CALIBRATION = R_S = 750 KΩ
LEAD WIRE RESISTANCE = R_L = 6Ω
BRIDGE RESISTANCE = R_A = 700Ω/ARM
EXCITATION VOLTAGE = E_{ex} = 10 VOLTS

GAGE FACTOR = F = 2.125
NUMBER OF ACTIVES = n = 2
POISSON'S RATIO = μ = .28
YOUNG'S MODULUS = E = 30×10⁶ PSI

SIMULATED STRESS FROM SHUNT AT GAGE

$$\sigma_S = E R_A / nF(1-\mu) R_S$$

$$= (30\times10^6)(700)/(2)(2.125)(.72)(750,000)$$

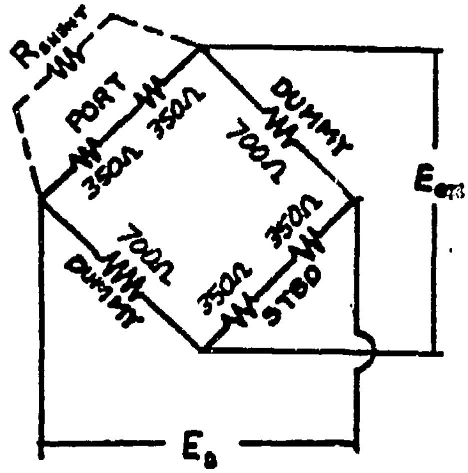
$$= 9,150 \text{ psi}$$

OUTPUT FROM GAGE SITE SHUNT = 2.23 VOLTS

SENSITIVITY = 9150 psi / 2.23 volts = 4100 psi/volt

POSITIVE VOLTS CORRESPONDS TO COMPRESSION OR SHIP SAG.

Figure B1 - Strain Bridge Circuits for Main Deck Bending



SHUNT CALIBRATION = R_s = 500 KΩ
LEAD WIRE RESISTANCE = R_L = 7Ω
BRIDGE RESISTANCE = R_A = 700Ω
EXCITATION VOLTAGE = E_{ex} = 10 volts

GAGE FACTOR = F = 2.125
NUMBER OF ACTIVES = n = 2
POISSON'S RATIO = μ = .28
YOUNG'S MODULUS = E = 30×10^6 psi

SIMULATED STRESS FROM SHUNT AT GAGE

$\sigma_s = ER_A / nFR_s$

$= (30 \times 10^6)(700)/(2)(2.125)(500,000)$

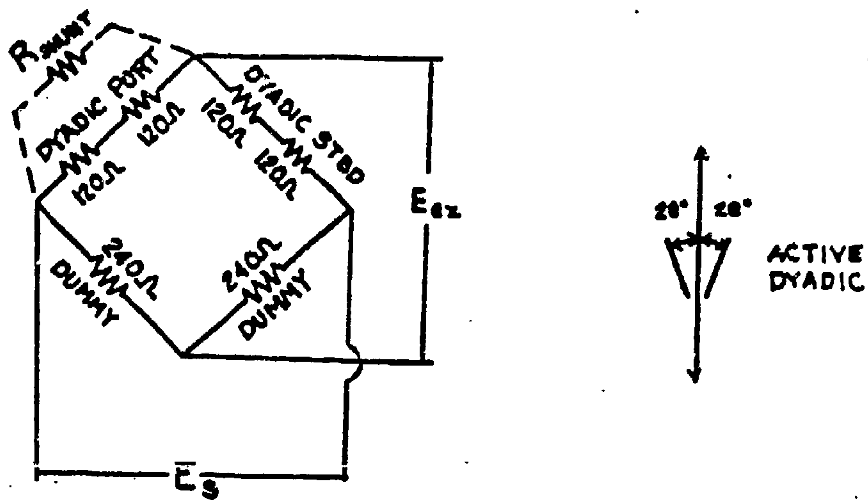
$= 9880$ psi

OUTPUT FROM GAGE SITE SHUNT = 3.38 volts

SENSITIVITY = 9880 psi/3.38 volts = 2900 psi/volt

POSITIVE VOLTS CORRESPONDS TO COMPRESSION OR SHIP HOG

Figure B2 - Strain Bridge Circuits for Bottom Bending



SHUNT CALIBRATION = R_s = 300KΩ
LEAD WIRE RESISTANCE = R_L = 7Ω
BRIDGE RESISTANCE = R_A = 240Ω/ARM
EXCITATION VOLTAGE = E_{ex} = 7 volts

GAGE FACTOR = F = 1.875
NUMBER OF ACTIVES = n = 2
POISSON'S RATIO = μ = .28
YOUNG'S MODULUS = E = 30×10^6 psi

SIMULATED STRESS FROM SHUNT AT GAGE

$$\sigma_s = E R_A / nF(1-\mu) R_s$$

$$= (30 \times 10^6)(240)/(2)(1.875)(.72)(300{,}000)$$

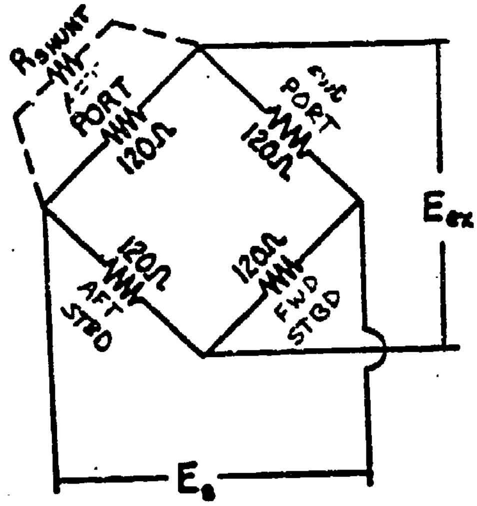
$$= 8890 \text{ psi}$$

OUTPUT FROM GAGE SITE SHUNT = 1.34 volts

SENSITIVITY = 8890 psi / 1.34 volts = 6640 psi/volt

POSITIVE VOLTS CORRESPONDS TO TENSION ON THE PORT SIDE

Figure B3 - Strain Bridge Circuits for Lateral Bending



SHUNT CALIBRATION: $R_s = 150\,K\Omega$ GAGE FACTOR: $F = 2.04$

LEAD WIRE RESISTANCE: $R_L = 7\,\Omega$ NUMBER OF ACTIVES: $n = 4$

BRIDGE RESISTANCE: $R_A = 120\,\Omega$/ARM POISSON'S RATIO: $\mu = .28$

EXCITATION VOLTAGE: $E_{ex} = 7$ VOLTS YOUNG'S MODULUS: $E = 30 \times 10^6$ psi

SIMULATED STRESS FROM SHUNT AT GAGE

$\sigma_s = ER_A / nF(1+\mu)R_s$

$= (30 \times 10^6)(120) / (4)(2.04)(1.28)(150{,}000)$

$= 2298$ psi

OUTPUT FROM GAGE SITE SHUNT = 1.26 VOLTS

SENSITIVITY = 2298 psi / 1.26 VOLTS = 1820 psi/VOLT

POSITIVE VOLTS CORRESPONDS TO STBD BOW UP

Figure B4 - Strain Bridge Circuits for Torsion

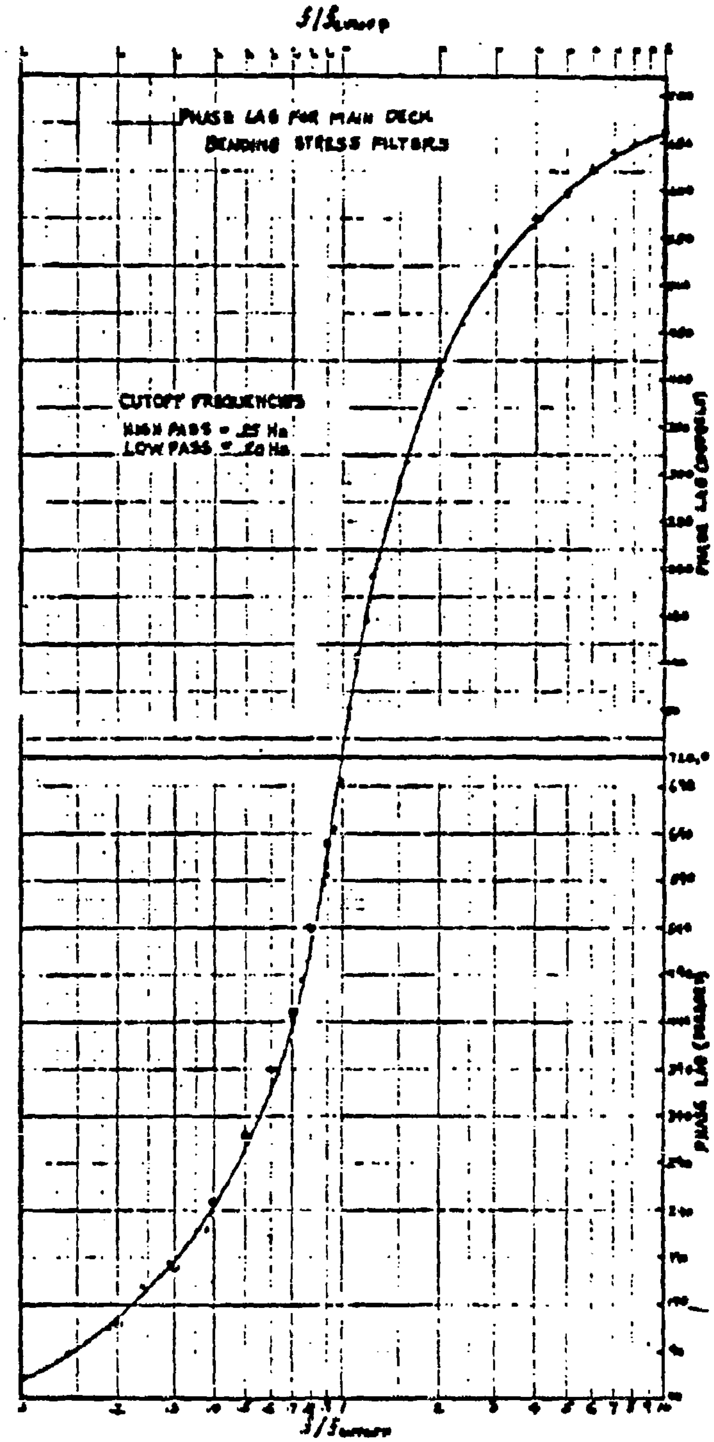


Figure B5 - Phase Lag Characteristics of Main Deck Bending Filters

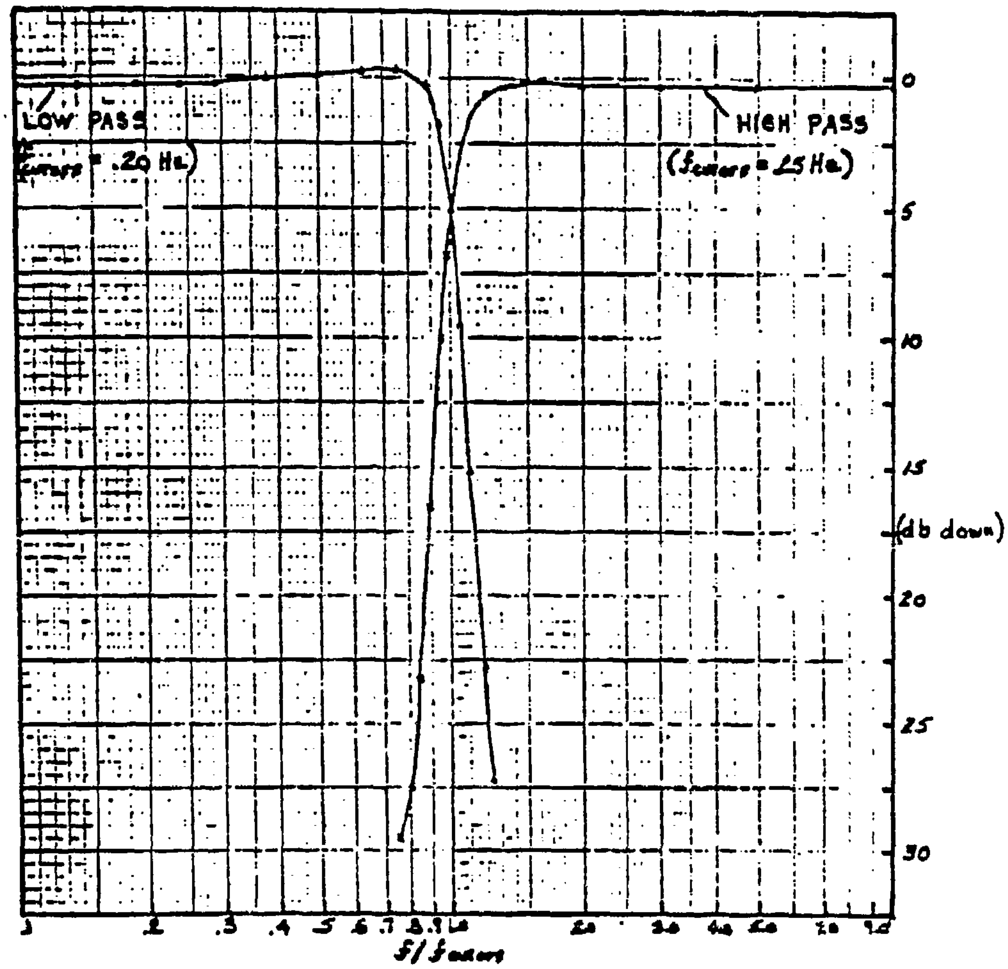
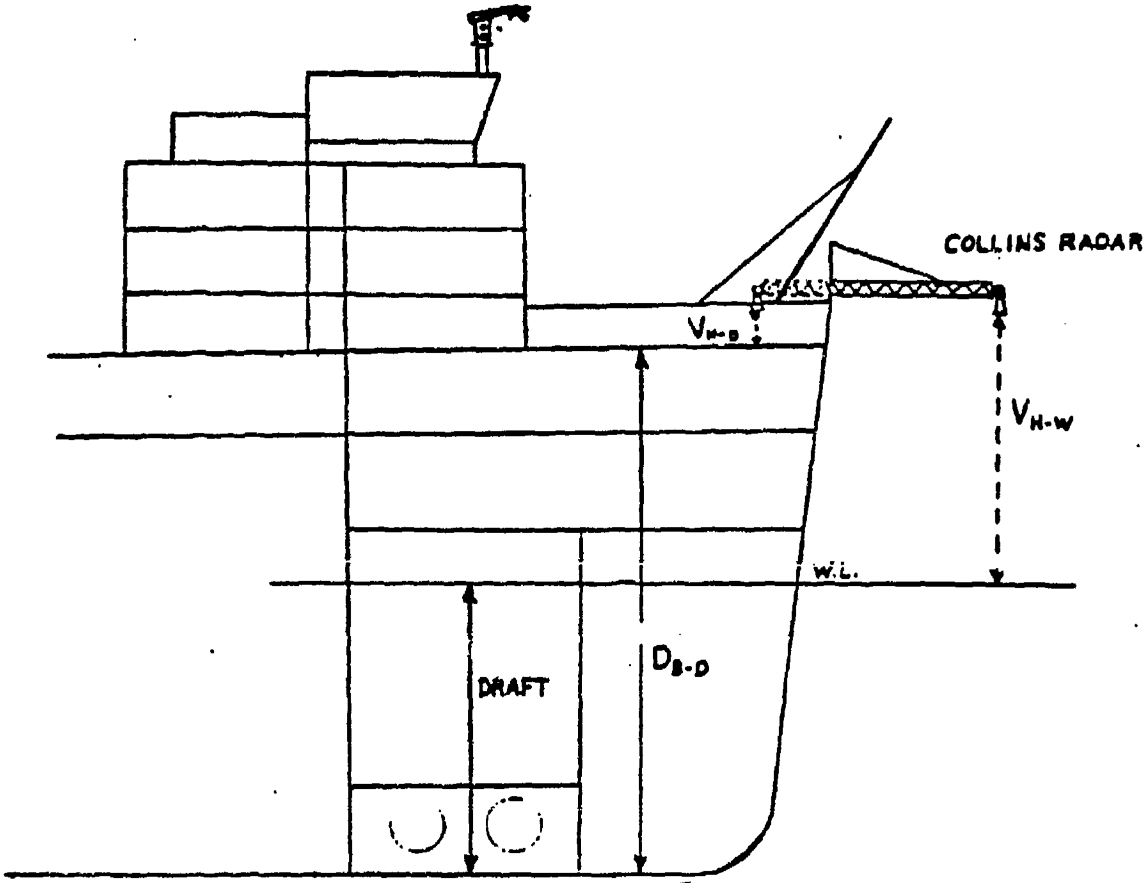


Figure B6 - Rolloff Characteristics of Main Deck Bending Filters



PROCEDURE FOR COLLINS RADAR RANGE CALIBRATION

1. POSITION RADAR HORNS VERTICALLY OVER WATER, TAKE VOLTAGE READING - V_{H-W}
2. SWING COLLINS HORNS IN OVER DECK AND TAKE SECOND READING - V_{H-D}
3. RECORD SHIP DRAFT

$$\text{RANGE SENSITIVITY} = \frac{D_{B-D} - \text{DRAFT}}{V_{H-W} - V_{H-D}} = \frac{\text{FT}}{\text{VOLT}} \text{ (DECREASING RANGE)}$$

TYPICALLY,

$$\text{SENSITIVITY} = \frac{(57.75 - 19.67)\,\text{FT}}{(.039 - 2.78)\,\text{VOLTS}} = -15.96\ \text{FT/VOLT (DECR. RANGE)}$$

WITH HORNS AT A 25° ANGLE THE SENSITIVITY $= \cos 25°(-15.96) = -14.5$ FT/VOLT

Figure B7 - Collins Radar Altimeter Calibration procedure

Table B1 - NRL INSTALLED TRANSDUCER SENSITIVITIES

MEASUREMENT	SENSITIVITY	SENSE
Collins Radar Range	14.50 ft/volt	Increasing Range @ 25° to Vertical
Collins Vertical Acceleration	1.855 $ft/sec^2/volt$	Acceleration Up
Collins Horizontal Acceleration	3.240 $ft/sec^2/volt$	Acceleration to STBD
NRL Range	24.61 ft/volt	Increasing Range
NRL Vertical Acceleration	1.408 $ft/sec^2/volt$	Acceleration Up
NRL Horizontal Acceleration	2.512 $ft/sec^2/volt$	Acceleration to Port

APPENDIX C
HEADER LOGS FOR M/V S.J. CORT DATA RUNS

A list of the header logs for each of the runs taken during the 1981 trials is provided in this appendix. The header logs list the ship conditions, speed, heading location and draft as well as wind and wave conditions at the start of each run. Also included are remark statements which give additional information about the run.

The location in terms of north latitude and west longitude were obtained from the Loran C tracking receiver used onboard. Vessel speed was obtained by the mates on watch by logging distance covered over a period of time. Direct speed was obtainable from the Loran C but was considered unreliable. Vessel heading was read directly from the ship's gyrocompass. The wind speed and direction are the true wind speed and direction existing at the start of each run. Wave height and direction are based upon visual estimates of the predominant sea at the start of each run. Sometimes the wave direction would be taken to be the same as the wind direction if the wind direction had been steady for a long period of time as the waves were building. The draft indicated in the header log was read off of the forward draft meter as the ship was underway. The other drafts were usually listed in the remark statements. An error in draft readings is evident when the ship is underway due to the effect of speed. True draft readings were taken when the ship was either in port or passing through the locks at Sault Ste. Marie. Runs 1-5 were taken with the ship ballasted between code 1 and code 2 with true drafts approximately 13'10" fwd, 16'3" amid, and 19'7" aft. Runs 6-12, 25-40, and 42-57, were taken with the ship in the loaded condition, with true drafts 27'0" fwd, 27'0" amid and 27'0" aft. The remaining runs 13-24 and run 41 were taken with the ship in the code 1 ballast condition, with true drafts 12'5" fwd, 15'8" amid, and 19'6" aft. These and other draft conditions are listed in Table C1.

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TABLE C1 - CORT DRAFTS FOR LOAD/BALLAST CONDITIONS

CONDITION	LOG ENTRY	DRAFT FWD	DRAFT AMID	DRAFT AFT
Ballast Code 1	12'-12'	12' -5"	15' -3"	19'-6"
Ballast Code 2	15'-16'	15'-4"	16'-11"	19'-8"
Ballast Code 3	17'-18'	17'-0"	18'-11"	21'-3"
Ballast Code 4	19'-20'	20'-7"	20'-7"	22'-0"
Ship Loaded	27'	27'-0"	27'-0"	27'-0"

```
M/V S J CORT FALL '81 TRIALS
          RUN          1            POINT          1
          DATE    10-NOV-81         TIME    11150128
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)           45 28
          WEST LONGITUDE (DD MM)           85 27
          VESSEL'S SPEED (MPH - XX.X)     15.4
          VESSEL'S HEADING (DEGREES)        36
          VESSEL'S DRAFT (FEET)              22
          WIND DIRECTION (DEGREES)         225
          WIND SPEED (KNOTS)                 32
          WAVE DIRECTION (DEGREES)         225
          WAVE HEIGHT (FEET)                  0
REMARKS
FOLLOWING SEAS APPROX 3.5 WAVE HEIGHT


End-of-run message
FOLLOWING SEAS, SL 7 NOT WORKING, DIGITIZING AT 5 SAM/SEC


M/V S J CORT FALL 81 TRIALS
          RUN          2            POINT          3
          DATE    11-NOV-81         TIME    01131133
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)           46 39
          WEST LONGITUDE (DD MM)           84 50
          VESSEL'S SPEED (MPH - XX.X)     14.8
          VESSEL'S HEADING (DEGREES)       332
          VESSEL'S DRAFT (FEET)              22
          WIND DIRECTION (DEGREES)         310
          WIND SPEED (KNOTS)                 28
          WAVE DIRECTION (DEGREES)         152
          WAVE HEIGHT (FEET)                  4
REMARKS
CODE 1+ HEAD SEAS


End-of-run message
4 FT WAVES, NEAR WHITEFISH POINT,SL 7 NOT WORKING,5 SPS


M/V S J CORT FALL 81 TRIALS
          RUN          3            POINT          5
          DATE    11-NOV-81         TIME    02115117
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)           46 49
          WEST LONGITUDE (DD MM)           85  3
          VESSEL'S SPEED (MPH - XX.X)     14.8
          VESSEL'S HEADING (DEGREES)       293
          VESSEL'S DRAFT (FEET)              22
          WIND DIRECTION (DEGREES)         320
          WIND SPEED (KNOTS)                 26
          WAVE DIRECTION (DEGREES)         310
          WAVE HEIGHT (FEET)                  3
REMARKS
CODE 1+ HEAD SEAS .


End-of-run message
SL 7 OUT,5 SPS, WAVES BUILDING SLOWLY


M/V S J CORT FALL 81 TRIALS
          RUN          4            POINT          7
          DATE    11-NOV-81         TIME    02129145
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)           46 52
          WEST LONGITUDE (DD MM)           85 14
          VESSEL'S SPEED (MPH - XX.X)     14.8
          VESSEL'S HEADING (DEGREES)       293
          VESSEL'S DRAFT (FEET)              23
          WIND DIRECTION (DEGREES)         313
          WIND SPEED (KNOTS)                 18
          WAVE DIRECTION (DEGREES)         313
          WAVE HEIGHT (FEET)                  3
REMARKS
CODE 1+ HEAD SEAS


End-of-run message
SL 7 OUT,5 SPS, HEAD-BOW.SEAS


M/V S J CORT FALL 81 TRIALS
          RUN          5            POINT          9
          DATE    11-NOV-81         TIME    03116118
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)           46 57
          WEST LONGITUDE (DD MM)           85 36
          VESSEL'S SPEED (MPH - XX.X)     15.3
          VESSEL'S HEADING (DEGREES)       293
          VESSEL'S DRAFT (FEET)              22
          WIND DIRECTION (DEGREES)         313
          WIND SPEED (KNOTS)                 1[illegible]
          WAVE DIRECTION (DEGREES)         310
          WAVE HEIGHT (FEET)                  3
REMARKS
CODE+1 BOW SEAS


End-of-run message
SL 7 OUT,WIND DIR 330,WIND SPD 18 KNTS, BOW SEAS


M/V S J CORT FALL 81 TRIALS
          RUN          6            POINT         11
          DATE    12-NOV-81         TIME    24114131
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)           47 21
          WEST LONGITUDE (DD MM)           86 53
          VESSEL'S SPEED (MPH - XX.X)     14.3
          VESSEL'S HEADING (DEGREES)       112
          VESSEL'S DRAFT (FEET)              24
          WIND DIRECTION (DEGREES)         182
          WIND SPEED (KNOTS)                 23
          WAVE DIRECTION (DEGREES)         18[illegible]
          WAVE HEIGHT (FEET)                  3
REMARKS
LOADED DNBND, DRAFTS 24,27,27,SL 7 OUT,5SP[illegible]


End-of-run message
LONG WAVES
```

```
M/V S J CORT FALL 81 TRIALS
         RUN           7         POINT           13
         DATE   12-NOV-81        TIME     24124105
         DURATION OF RUN IN MINUTES IS         25.000
         NORTH LATITUDE (DD MM)          47 18
         WEST LONGITUDE (DD MM)          86 41
         VESSEL'S SPEED (MPH - XX.X)    14.3
         VESSEL'S HEADING (DEGREES)      112
         VESSEL'S DRAFT (FEET)            24
         WIND DIRECTION (DEGREES)        182
         WIND SPEED (KNOTS)               23
         WAVE DIRECTION (DEGREES)        182
         WAVE HEIGHT (FEET)                4
REMARKS
HEADED TOWARD WHITEFISH BAY
LOADED DNBND,DRAFTS 24,27,27, SL 7 OUT,5 SPS

End-of-run message
4-5 FT BEAM SEAS
```

```
M/V S J CORT FALL 81 TRIALS
         RUN           8         POINT           15
         DATE   12-NOV-81        TIME     24134112
         DURATION OF RUN IN MINUTES IS         25.000
         NORTH LATITUDE (DD MM)          47 15
         WEST LONGITUDE (DD MM)          86 31
         VESSEL'S SPEED (MPH - XX.X)    14.3
         VESSEL'S HEADING (DEGREES)      112
         VESSEL'S DRAFT (FEET)            24
         WIND DIRECTION (DEGREES)        192
         WIND SPEED (KNOTS)               28
         WAVE DIRECTION (DEGREES)        192
         WAVE HEIGHT (FEET)                5
REMARKS
HEADED TOWARD WHITEFISH BAY
LOADED DNBND,DRAFTS 24,27,27, SL 7 OUT,5 SPS

End-of-run message
4-5FT BEAM SEAS
```

```
M/V S J CORT FALL 81 TRIALS
         RUN           9         POINT           17
         DATE   12-NOV-81        TIME     24140155
         DURATION OF RUN IN MINUTES IS         25.000
         NORTH LATITUDE (DD MM)          47 13
         WEST LONGITUDE (DD MM)          86 23
         VESSEL'S SPEED (MPH - XX.X)    14.3
         VESSEL'S HEADING (DEGREES)      112
         VESSEL'S DRAFT (FEET)            24
         WIND DIRECTION (DEGREES)        192
         WIND SPEED (KNOTS)               28
         WAVE DIRECTION (DEGREES)        192
         WAVE HEIGHT (FEET)                5
REMARKS
HEADED TOWARD WHITEFISH BAY
LOADED DNBND,DRAFTS 24,27,27, SL 7 OUT,5 SPS

End-of-run message
3-4 FT BEAM SEAS,DA 13-NOV-81, TI 02123100
```

```
M/V S J CORT FALL 81 TRIALS
         RUN          10         POINT           19
         DATE   14-NOV-81        TIME     01143124
         DURATION OF RUN IN MINUTES IS         25.000
         NORTH LATITUDE (DD MM)          45 37
         WEST LONGITUDE (DD MM)          86  8
         VESSEL'S SPEED (MPH - XX.X)    14.2
         VESSEL'S HEADING (DEGREES)      203
         VESSEL'S DRAFT (FEET)            24
         WIND DIRECTION (DEGREES)        200
         WIND SPEED (KNOTS)               16
         WAVE DIRECTION (DEGREES)        200
         WAVE HEIGHT (FEET)                3
REMARKS
NORTHERN MICHIGAN,DNBND,DRAFTS 24,27,27
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SEAS 3 FT
```

```
M/V S J CORT FALL 81 TRIALS
         RUN          11         POINT           21
         DATE   14-NOV-81        TIME     01151158
         DURATION OF RUN IN MINUTES IS         25.000
         NORTH LATITUDE (DD MM)          45 30
         WEST LONGITUDE (DD MM)          86 12
         VESSEL'S SPEED (MPH - XX.X)    14.2
         VESSEL'S HEADING (DEGREES)      203
         VESSEL'S DRAFT (FEET)            24
         WIND DIRECTION (DEGREES)        187
         WIND SPEED (KNOTS)               16
         WAVE DIRECTION (DEGREES)        187
         WAVE HEIGHT (FEET)                3
REMARKS
NORTHERN MICHIGAN,DNBND,DRAFTS 24,27,27
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SEAS 3 FT
```

```
M/V S J CORT FALL 81 TRIALS
         RUN          12         POINT           23
         DATE   14-NOV-81        TIME     02128146
         DURATION OF RUN IN MINUTES IS         25.000
         NORTH LATITUDE (DD MM)          45 19
         WEST LONGITUDE (DD MM)          86 19
         VESSEL'S SPEED (MPH - XX.X)    14.2
         VESSEL'S HEADING (DEGREES)      203
         VESSEL'S DRAFT (FEET)            24
         WIND DIRECTION (DEGREES)        182
         WIND SPEED (KNOTS)               15
         WAVE DIRECTION (DEGREES)        182
         WAVE HEIGHT (FEET)                3
REMARKS
NORTHERN MICHIGAN,DNBND,DRAFTS 24,27,27
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SEAS 3 FT
```

```
M/V S J CORT FALL 81 TRIALS
        RUN            13          POINT          25
        DATE    17-NOV-81          TIME     06:41:08
        DURATION OF RUN IN MINUTES IS         25.000
        NORTH LATITUDE (DD MM)            47 15
        WEST LONGITUDE (DD MM)            86 46
        VESSEL'S SPEED (MPH - XX.X)      15.3
        VESSEL'S HEADING (DEGREES)        290
        VESSEL'S DRAFT (FEET)              10
        WIND DIRECTION (DEGREES)          290
        WIND SPEED (KNOTS)                 18
        WAVE DIRECTION (DEGREES)          290
        WAVE HEIGHT (FEET)                  3
REMARKS
UPBND SUPERIOR DRAFTS 10,16.5,21,5,
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SEAS, 2-3 FT, ACTUAL FWD DRAFT 11'11"
```

```
M/V S J CORT FALL 81 TRIALS
        RUN            14          POINT          27
        DATE    17-NOV-81          TIME     06:51:59
        DURATION OF RUN IN MINUTES IS         25.000
        NORTH LATITUDE (DD MM)            47 19
        WEST LONGITUDE (DD MM)            86 59
        VESSEL'S SPEED (MPH - XX.X)      15.3
        VESSEL'S HEADING (DEGREES)        291
        VESSEL'S DRAFT (FEET)              10
        WIND DIRECTION (DEGREES)          290
        WIND SPEED (KNOTS)                 18
        WAVE DIRECTION (DEGREES)          290
        WAVE HEIGHT (FEET)                  3
REMARKS
UPBND SUPERIOR DRAFTS 10,16.5,21,5,
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SEAS 3-4 FT ,CODE 1 ,ACUAL FWD DRAFT 12 FT
```

```
M/V S J CORT FALL 81 TRIALS
        RUN            15          POINT          29
        DATE    17-NOV-81          TIME     07:19:42
        DURATION OF RUN IN MINUTES IS         25.000
        NORTH LATITUDE (DD MM)            47 23
        WEST LONGITUDE (DD MM)            87 14
        VESSEL'S SPEED (MPH - XX.X)      15.1
        VESSEL'S HEADING (DEGREES)        291
        VESSEL'S DRAFT (FEET)              10
        WIND DIRECTION (DEGREES)          297
        WIND SPEED (KNOTS)                 18
        WAVE DIRECTION (DEGREES)          297
        WAVE HEIGHT (FEET)                  4
REMARKS
UPBND SUPERIOR DRAFTS 10,16.5,21,5,
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SEAS,4-5 FT,EAST OF KEWEENAW PT.TI 08:33
```

```
M/V S J CORT FALL 81 TRIALS
        RUN            16          POINT          31
        DATE    17-NOV-81          TIME     07:25:41
        DURATION OF RUN IN MINUTES IS         25.000
        NORTH LATITUDE (DD MM)            47 25
        WEST LONGITUDE (DD MM)            87 24
        VESSEL'S SPEED (MPH - XX.X)      15.1
        VESSEL'S HEADING (DEGREES)        291
        VESSEL'S DRAFT (FEET)              10
        WIND DIRECTION (DEGREES)          297
        WIND SPEED (KNOTS)                 18
        WAVE DIRECTION (DEGREES)          297
        WAVE HEIGHT (FEET)                  4
REMARKS
UPBND SUPERIOR DRAFTS 10,16.5,21,5,
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SEAS,4-5 FT, TI 09:04 , CODE 1
```

```
M/V S J CORT FALL 81 TRIALS
        RUN            17          POINT          33
        DATE    17-NOV-81          TIME     10:17:01
        DURATION OF RUN IN MINUTES IS         28.000
        NORTH LATITUDE (DD MM)            47 31
        WEST LONGITUDE (DD MM)            87 52
        VESSEL'S SPEED (MPH - XX.X)      14.3
        VESSEL'S HEADING (DEGREES)        266
        VESSEL'S DRAFT (FEET)              10
        WIND DIRECTION (DEGREES)          276
        WIND SPEED (KNOTS)                 20
        WAVE DIRECTION (DEGREES)          276
        WAVE HEIGHT (FEET)                  4
REMARKS
UPBND SUPERIOR DRAFTS 10,16.5,21,5,
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD-BOW SEAS,TI 10:43
```

```
M/V S J CORT FALL 81 TRIALS
        RUN            18          POINT          35
        DATE    17-NOV-81          TIME     10:21:03
        DURATION OF RUN IN MINUTES IS         25.000
        NORTH LATITUDE (DD MM)            47 30
        WEST LONGITUDE (DD MM)            88  0
        VESSEL'S SPEED (MPH - XX.X)      14.3
        VESSEL'S HEADING (DEGREES)        266
        VESSEL'S DRAFT (FEET)              10
        WIND DIRECTION (DEGREES)          276
        WIND SPEED (KNOTS)                 20
        WAVE DIRECTION (DEGREES)          276
        WAVE HEIGHT (FEET)                  3
REMARKS
UPBND SUPERIOR DRAFTS 10,16.5,21,5,
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
HHEAD-BOW SEAS,2-3 FT ,CODE 1 ,TI 11:13
```

```
M/V S J CORT FALL 81 TRIALS
        RUN             19          POINT          37
        DATE    17-NOV-81           TIME     10:27:12
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)            47 30
        WEST LONGITUDE (DD MM)            88 11
        VESSEL'S SPEED (MPH - XX.X)       14.3
        VESSEL'S HEADING (DEGREES)        258
        VESSEL'S DRAFT (FEET)               10
        WIND DIRECTION (DEGREES)          273
        WIND SPEED (KNOTS)                  20
        WAVE DIRECTION (DEGREES)          273
        WAVE HEIGHT (FEET)                   3
REMARKS
UPBND SUPERIOR DRAFTS 10,14.5,21.5,
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD-BOW SEAS,2-3 FT, CODE 1, TI 11:44
```

```
M/V S J CORT FALL '81 TRIALS
        RUN             20          POINT          39
        DATE    17-NOV-81           TIME     13:42:43
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)            47 24
        WEST LONGITUDE (DD MM)            88 53
        VESSEL'S SPEED (MPH - XX.X)       14.6
        VESSEL'S HEADING (DEGREES)        259
        VESSEL'S DRAFT (FEET)               10
        WIND DIRECTION (DEGREES)          275
        WIND SPEED (KNOTS)                  24
        WAVE DIRECTION (DEGREES)          275
        WAVE HEIGHT (FEET)                   3
REMARKS
UPBND SUPERIOR, DRAFTS 10,16.5,21.75, CODE 1
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
STBD BOW 4-5 FT , TI 14:10
```

```
M/V S J CORT FALL '81 TRIALS
        RUN             21          POINT          41
        DATE    17-NOV-81           TIME     13:49:34
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)            47 22
        WEST LONGITUDE (DD MM)            89  4
        VESSEL'S SPEED (MPH - XX.X)       14.6
        VESSEL'S HEADING (DEGREES)        259
        VESSEL'S DRAFT (FEET)               10
        WIND DIRECTION (DEGREES)          275
        WIND SPEED (KNOTS)                  24
        WAVE DIRECTION (DEGREES)          275
        WAVE HEIGHT (FEET)                   4
REMARKS.
UPBND SUPERIOR, DRAFTS 10,16.5,21.75, CODE 1
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
STBD BOW SEAS 4-5 FT TI 14:41
```

```
M/V S J CORT FALL '81 TRIALS
        RUN             22          POINT          43
        DATE    17-NOV-81           TIME     13:55:24
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)            47 21
        WEST LONGITUDE (DD MM)            89 14
        VESSEL'S SPEED (MPH - XX.X)       14.6
        VESSEL'S HEADING (DEGREES)        259
        VESSEL'S DRAFT (FEET)               10
        WIND DIRECTION (DEGREES)          275
        WIND SPEED (KNOTS)                  24
        WAVE DIRECTION (DEGREES)          275
        WAVE HEIGHT (FEET)                   4
REMARKS
UPBND SUPERIOR, DRAFTS 10,16.5,21.75, CODE 1
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
STBD BOW SEAS, 4-5 FT, TI 15:11
```

```
M/V S J CORT FALL '81 TRIALS
        RUN             23          POINT          45
        DATE    17-NOV-81           TIME     16:14:42
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)            47 16
        WEST LONGITUDE (DD MM)            89 40
        VESSEL'S SPEED (MPH - XX.X)       15.1
        VESSEL'S HEADING (DEGREES)        259
        VESSEL'S DRAFT (FEET)               10
        WIND DIRECTION (DEGREES)          280
        WIND SPEED (KNOTS)                  20
        WAVE DIRECTION (DEGREES)          280
        WAVE HEIGHT (FEET)                   3
REMARKS
UPBND SUPERIOR, DRAFTS 10,16.5,21.75, CODE 1
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
STBD SEAS BOW, 3-4 FT TI 16:41
```

```
M/V S J CORT FALL '81 TRIALS
        RUN             24          POINT          47
        DATE    17-NOV-81           TIME     17:03:26
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)            47 13
        WEST LONGITUDE (DD MM)            90  2
        VESSEL'S SPEED (MPH - XX.X)       15.1
        VESSEL'S HEADING (DEGREES)        259
        VESSEL'S DRAFT (FEET)               10
        WIND DIRECTION (DEGREES)          280
        WIND SPEED (KNOTS)                  20
        WAVE DIRECTION (DEGREES)          280
        WAVE HEIGHT (FEET)                   3
REMARKS
UPBND SUPERIOR, DRAFTS 10,17,22, CODE 1
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
BOW SEAS STBD, 2-3 FT, TI 17:55
```

```
M/V S J CORT FALL '81 TRIALS
        RUN                      25          POINT          49
        DATE    18-NOV-81                    TIME     14:33:00
        DURATION OF RUN IN MINUTES IS                  25.000
        NORTH LATITUDE (DD MM)              47 23
        WEST LONGITUDE (DD MM)              89 25
        VESSEL'S SPEED (MPH - XX.X)        14.1
        VESSEL'S HEADING (DEGREES)          77
        VESSEL'S DRAFT (FEET)                24
        WIND DIRECTION (DEGREES)            10
        WIND SPEED (KNOTS)                   14
        WAVE DIRECTION (DEGREES)            10
        WAVE HEIGHT (FEET)                    2
REMARKS
DNBND SUPERIOR, DRAFTS 24,27,26.75
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
BOW BEAM SEAS, 1-2 FT, TI 14:58
```

```
M/V S J CORT FALL '81 TRIALS
        RUN                      26          POINT          51
        DATE    18-NOV-81                    TIME     14:38:17
        DURATION OF RUN IN MINUTES IS                  25.000
        NORTH LATITUDE (DD MM)              47 25
        WEST LONGITUDE (DD MM)              89 14
        VESSEL'S SPEED (MPH - XX.X)        14.1
        VESSEL'S HEADING (DEGREES)          77
        VESSEL'S DRAFT (FEET)                24
        WIND DIRECTION (DEGREES)            10
        WIND SPEED (KNOTS)                   14
        WAVE DIRECTION (DEGREES)            10
        WAVE HEIGHT (FEET)                    2
REMARKS
DNBND SUPERIOR, DRAFTS 24,27,26.75
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
BOW-BEAM SEAS, 1-2 FT, TI 15:29
```

```
M/V S J CORT FALL '81 TRIALS
        RUN                      27          POINT          53
        DATE    18-NOV-81                    TIME     17:46:44
        DURATION OF RUN IN MINUTES IS                  25.000
        NORTH LATITUDE (DD MM)              47 31
        WEST LONGITUDE (DD MM)              88 27
        VESSEL'S SPEED (MPH - XX.X)        14.1
        VESSEL'S HEADING (DEGREES)          77
        VESSEL'S DRAFT (FEET)                24
        WIND DIRECTION (DEGREES)           355
        WIND SPEED (KNOTS)                   20
        WAVE DIRECTION (DEGREES)           355
        WAVE HEIGHT (FEET)                    3
REMARKS
DNBND SUPERIOR, DRAFTS 24.25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
BOW-BEAM SEAS, 4-5 FT, TI 18:10
```

```
M/V S J CORT FALL '81 TRIALS
        RUN                      28          POINT          55
        DATE    18-NOV-81                    TIME     18:12:01
        DURATION OF RUN IN MINUTES IS                  25.000
        NORTH LATITUDE (DD MM)              47 34
        WEST LONGITUDE (DD MM)              88 11
        VESSEL'S SPEED (MPH - XX.X)        14.1
        VESSEL'S HEADING (DEGREES)          80
        VESSEL'S DRAFT (FEET)                24
        WIND DIRECTION (DEGREES)              5
        WIND SPEED (KNOTS)                   26
        WAVE DIRECTION (DEGREES)           355
        WAVE HEIGHT (FEET)                    4
REMARKS
DNBND SUPERIOR, DRAFTS 24.25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
BEAM SEAS, 4-5 FT ,TI 18:59
```

```
M/V S J CORT FALL '81 TRIALS
        RUN                      29          POINT          57
        DATE    18-NOV-81                    TIME     18:17:25
        DURATION OF RUN IN MINUTES IS                  25.000
        NORTH LATITUDE (DD MM)              47 35
        WEST LONGITUDE (DD MM)              88  2
        VESSEL'S SPEED (MPH - XX.X)        14.1
        VESSEL'S HEADING (DEGREES)          80
        VESSEL'S DRAFT (FEET)                24
        WIND DIRECTION (DEGREES)              5
        WIND SPEED (KNOTS)                   26
        WAVE DIRECTION (DEGREES)              5
        WAVE HEIGHT (FEET)                    4
REMARKS
DNBND SUPERIOR, DRAFTS 24.25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
BEAM SEAS, 4-5 FT, TI 17:32
```

```
M/V S J CORT FALL '81 TRIALS
        RUN                      30          POINT          59
        DATE    18-NOV-81                    TIME     18:47:01
        DURATION OF RUN IN MINUTES IS                  25.000
        NORTH LATITUDE (DD MM)              47 35
        WEST LONGITUDE (DD MM)              87 46
        VESSEL'S SPEED (MPH - XX.X)        14.2
        VESSEL'S HEADING (DEGREES)          90
        VESSEL'S DRAFT (FEET)                24
        WIND DIRECTION (DEGREES)              0
        WIND SPEED (KNOTS)                   23
        WAVE DIRECTION (DEGREES)              0
        WAVE HEIGHT (FEET)                    4
REMARKS
DNBND SUPERIOR, DRAFTS 24.25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
PORT BEAM,4-5FT, TI 20:27
```

```
M/V S J CORT FALL '81 TRIALS
        RUN              31          POINT          41
        DATE    18-NOV-81            TIME     18153106
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)            47 35
        WEST LONGITUDE (DD MM)            87 34
        VESSEL'S SPEED (MPH - XX.X)      14.2
        VESSEL'S HEADING (DEGREES)        90
        VESSEL'S DRAFT (FEET)              24
        WIND DIRECTION (DEGREES)          0
        WIND SPEED (KNOTS)                23
        WAVE DIRECTION (DEGREES)          0
        WAVE HEIGHT (FEET)                  4
REMARKS
DNBND SUPERIOR, DRAFTS 24.25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
STERN QUARTERING SEAS ,HEADING CHANGE TO 113 ,3 MINUTES INTO RUN


M/V S J CORT FALL '81 TRIALS
        RUN              32          POINT          63
        DATE    19-NOV-81            TIME     04153107
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)            46 55
        WEST LONGITUDE (DD MM)            85 21
        VESSEL'S SPEED (MPH - XX.X)      14.2
        VESSEL'S HEADING (DEGREES)        111
        VESSEL'S DRAFT (FEET)              24
        WIND DIRECTION (DEGREES)          40
        WIND SPEED (KNOTS)                 18
        WAVE DIRECTION (DEGREES)          40
        WAVE HEIGHT (FEET)                  3
REMARKS
DNBND SUPERIOR, DRAFTS 24.25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
PORT BEAM,,RADIO COMMS 12 MIN INTO RUN, TI 5118


M/V S J CORT FALL '81 TRIALS
        RUN              33          POINT          65
        DATE    19-NOV-81            TIME     04159101
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)            46 52
        WEST LONGITUDE (DD MM)            85  9
        VESSEL'S SPEED (MPH - XX.X)      14.2
        VESSEL'S HEADING (DEGREES)        111
        VESSEL'S DRAFT (FEET)              24
        WIND DIRECTION (DEGREES)          40
        WIND SPEED (KNOTS)                 18
        WAVE DIRECTION (DEGREES)          40
        WAVE HEIGHT (FEET)                  3
REMARKS
DNBND SUPERIOR, DRAFTS 24.25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
BEAM SEAS PORT, 3-4 FT, TI 5150
```

END TAPE 1

```
M/V S J CORT FALL '81 TRIALS
         RUN          34            POINT          1
         DATE    20-NOV-81          TIME    08128113
         DURATION OF RUN IN MINUTES IS           25.000
         NORTH LATITUDE (DD MM)           44 15
         WEST LONGITUDE (DD MM)           86 47
         VESSEL'S SPEED (MPH - XX.X)    14.3
         VESSEL'S HEADING (DEGREES)       185
         VESSEL'S DRAFT (FEET)              24
         WIND DIRECTION (DEGREES)         360
         WIND SPEED (KNOTS)                 32
         WAVE DIRECTION (DEGREES)         360
         WAVE HEIGHT (FEET)                  6
REMARKS
DNBND MICHIGAN, DRAFTS 24.25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
FOLLOWING SEAS, 6 FT , TI8154
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```
M/V S J CORT FALL '81 TRIALS
         RUN          35            POINT          3
         DATE    20-NOV-81          TIME    08132128
         DURATION OF RUN IN MINUTES IS           25.000
         NORTH LATITUDE (DD MM)           44  9
         WEST LONGITUDE (DD MM)           86 48
         VESSEL'S SPEED (MPH - XX.X)    14.3
         VESSEL'S HEADING (DEGREES)       185
         VESSEL'S DRAFT (FEET)              24
         WIND DIRECTION (DEGREES)         360
         WIND SPEED (KNOTS)                 32
         WAVE DIRECTION (DEGREES)         360
         WAVE HEIGHT (FEET)                  6
REMARKS
DNBND MICHIGAN, DRAFTS 24.25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
FOLLOWING SEAS, 6-7 FT, TI 9123
```

```
M/V S J CORT FALL '81 TRIALS
         RUN          34            POINT          5
         DATE    20-NOV-81          TIME    13100143
         DURATION OF RUN IN MINUTES IS           25.000
         NORTH LATITUDE (DD MM)           43 21
         WEST LONGITUDE (DD MM)           86 55
         VESSEL'S SPEED (MPH - XX.X)    14.3
         VESSEL'S HEADING (DEGREES)       184
         VESSEL'S DRAFT (FEET)              24
         WIND DIRECTION (DEGREES)         320
         WIND SPEED (KNOTS)                 38
         WAVE DIRECTION (DEGREES)         320
         WAVE HEIGHT (FEET)                  6
REMARKS
DNBND MICHIGAN, DRAFTS 24.25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
FOLLOWING SEAS, 7-8 FT,TI 13124
```

```
M/V S J CORT FALL '81 TRIALS
         RUN          37            POINT          7
         DATE    20-NOV-81          TIME    13104134
         DURATION OF RUN IN MINUTES IS           25.000
         NORTH LATITUDE (DD MM)           43 14
         WEST LONGITUDE (DD MM)           86 56
         VESSEL'S SPEED (MPH - XX.X)    14.3
         VESSEL'S HEADING (DEGREES)       184
         VESSEL'S DRAFT (FEET)              24
         WIND DIRECTION (DEGREES)         320
         WIND SPEED (KNOTS)                 38
         WAVE DIRECTION (DEGREES)         320
         WAVE HEIGHT (FEET)                  6
REMARKS
DNBND MICHIGAN, DRAFTS 24.25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
FOLLOWING STBD QUARTER, 6-7 FT, TI 13155
```

```
M/V S J CORT FALL '81 TRIALS
         RUN          38            POINT          9
         DATE    20-NOV-81          TIME    13114126
         DURATION OF RUN IN MINUTES IS           25.000
         NORTH LATITUDE (DD MM)           43  7
         WEST LONGITUDE (DD MM)           86 57
         VESSEL'S SPEED (MPH - XX.X)    14.3
         VESSEL'S HEADING (DEGREES)       184
         VESSEL'S DRAFT (FEET)              24
         WIND DIRECTION (DEGREES)         313
         WIND SPEED (KNOTS)                 34
         WAVE DIRECTION (DEGREES)         313
         WAVE HEIGHT (FEET)                  6
REMARKS
DNBND MICHIGAN, DRAFTS 24.25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
FOLL SBRD STERN, RADIO COMMS DURING LAST 1.5 MINS,TI 14130
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```
M/V S J CORT FALL '81 TRIALS
         RUN          39            POINT         11
         DATE    20-NOV-81          TIME    13124139
         DURATION OF RUN IN MINUTES IS           25.000
         NORTH LATITUDE (DD MM)           42 59
         WEST LONGITUDE (DD MM)           86 58
         VESSEL'S SPEED (MPH - XX.X)    14.3
         VESSEL'S HEADING (DEGREES)       184
         VESSEL'S DRAFT (FEET)              24
         WIND DIRECTION (DEGREES)         313
         WIND SPEED (KNOTS)                 34
         WAVE DIRECTION (DEGREES)         313
         WAVE HEIGHT (FEET)                  6
REMARKS
DNBND MICHIGAN, DRAFTS 24.25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPS

End-of-run message
FOLL STBD QUARTER, 6-7 FT, TI 15105
```

```
M/V S J CORT FALL '81 TRIALS
     RUN            40            POINT            13
     DATE    20-NOV-81            TIME       13158110
     DURATION OF RUN IN MINUTES IS             25.000
     NORTH LATITUDE (DD MM)              42 50
     WEST LONGITUDE (DD MM)              86 58
     VESSEL'S SPEED (MPH - XX.X)        14.3
     VESSEL'S HEADING (DEGREES)          186
     VESSEL'S DRAFT (FEET)                 24
     WIND DIRECTION (DEGREES)            315
     WIND SPEED (KNOTS)                    34
     WAVE DIRECTION (DEGREES)            315
     WAVE HEIGHT (FEET)                     6
REMARKS
DNBND MICHIGAN, DRAFTS 24,25,27,26.5
SL 7 & SL 7 H ACC OUT, 5 SPB

End-of-run message
FOLL STBD QUARTER, 6-7FT ,TI 14103
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```
M/V S J CORT FALL '81 TRIALS
     RUN            41            POINT            15
     DATE    05-NOV-81            TIME       09120102
     DURATION OF RUN IN MINUTES IS             25.000
     NORTH LATITUDE (DD MM)              46 37
     WEST LONGITUDE (DD MM)              84 40
     VESSEL'S SPEED (MPH - XX.X)        13.8
     VESSEL'S HEADING (DEGREES)          329
     VESSEL'S DRAFT (FEET)                 12
     WIND DIRECTION (DEGREES)            340
     WIND SPEED (KNOTS)                    25
     WAVE DIRECTION (DEGREES)            340
     WAVE HEIGHT (FEET)                     3
REMARKS
UPBND WHITEFISH BAY, DRAFTS 11,17,21.5, CODE 1
SL 7, SL7 H ACC, & TAIL BEND OUT, 5 SPB

End-of-run message
HEAD SAES
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```
M/V S J CORT FALL '81 TRIALS
     RUN            42            POINT            17
     DATE    08-DEC-81            TIME       09149100
     DURATION OF RUN IN MINUTES IS             25.000
     NORTH LATITUDE (DD MM)              45 50
     WEST LONGITUDE (DD MM)              84 58
     VESSEL'S SPEED (MPH - XX.X)        13.5
     VESSEL'S HEADING (DEGREES)          279
     VESSEL'S DRAFT (FEET)                 27
     WIND DIRECTION (DEGREES)            345
     WIND SPEED (KNOTS)                    23
     WAVE DIRECTION (DEGREES)            345
     WAVE HEIGHT (FEET)                     3
REMARKS
DNBND NORTHERN LAKE MICHIGAN DRAFTS 24, 26 10, 26 7
SL 7 AND SL 7 H ACC OUT, 5 SPB

End-of-run message
STBD BOW, TI 10:115
```

```
M/V S J CORT FALL '81 TRIALS
     RUN            43            POINT            19
     DATE    08-DEC-81            TIME       09156102
     DURATION OF RUN IN MINUTES IS             25.000
     NORTH LATITUDE (DD MM)              45 52
     WEST LONGITUDE (DD MM)              85 10
     VESSEL'S SPEED (MPH - XX.X)        13.5
     VESSEL'S HEADING (DEGREES)          279
     VESSEL'S DRAFT (FEET)                 27
     WIND DIRECTION (DEGREES)            345
     WIND SPEED (KNOTS)                    23
     WAVE DIRECTION (DEGREES)            345
     WAVE HEIGHT (FEET)                     3
REMARKS
DNBND NORTHERN LAKE MICHIGAN DRAFTS 24 7, 26 10, 26 9
SL 7 AND SL 7 H ACC OUT, 5 SPB

End-of-run message
STBD BEAM TI 10146
```

```
M/V S J CORT FALL '81 TRIALS
     RUN            44            POINT            21
     DATE    08-DEC-81            TIME       10103115
     DURATION OF RUN IN MINUTES IS             25.000
     NORTH LATITUDE (DD MM)              45 53
     WEST LONGITUDE (DD MM)              85 19
     VESSEL'S SPEED (MPH - XX.X)        14.1
     VESSEL'S HEADING (DEGREES)          277
     VESSEL'S DRAFT (FEET)                 27
     WIND DIRECTION (DEGREES)               0
     WIND SPEED (KNOTS)                    28
     WAVE DIRECTION (DEGREES)               0
     WAVE HEIGHT (FEET)                     3
REMARKS
DNBND NORTHERN LAKE MICHIGAN DRAFTS 24 7, 26 10, 26 9
SL 7 AND SL 7 H ACC OUT, 5 SPB

End-of-run message
STBD BEAM TI11119
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```
M/V S J CORT FALL '81 TRIALS
     RUN            45            POINT            23
     DATE    08-DEC-81            TIME       14107129
     DURATION OF RUN IN MINUTES IS             25.000
     NORTH LATITUDE (DD MM)              45 40
     WEST LONGITUDE (DD MM)              86  9
     VESSEL'S SPEED (MPH - XX.X)        14.2
     VESSEL'S HEADING (DEGREES)          241
     VESSEL'S DRAFT (FEET)                 27
     WIND DIRECTION (DEGREES)            358
     WIND SPEED (KNOTS)                    28
     WAVE DIRECTION (DEGREES)            358
     WAVE HEIGHT (FEET)                     4
REMARKS
DNBND MICHIGAN, DRAFTS 23 10, 26 10, 26 5
SL 7 AND SL 7 H ACC OUT, 5 SPB

End-of-run message
STBD BEAM STERN QUARTER TI 14133
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```
M/V S J CORT FALL '81 TRIALS
        RUN           46          POINT          25
        DATE    08-DEC-81         TIME     17109115
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)          45  5
        WEST LONGITUDE (DD MM)          86 42
        VESSEL'S SPEED (MPH - XX.X)    14.1
        VESSEL'S HEADING (DEGREES)     205
        VESSEL'S DRAFT (FEET)            27
        WIND DIRECTION (DEGREES)          0
        WIND SPEED (KNOTS)               20
        WAVE DIRECTION (DEGREES)          0
        WAVE HEIGHT (FEET)                5
REMARKS
DNBND MICHIGAN, DRAFTS 23 8, 26 10, 26 2
SL 7 AND SL 7 H ACC OUT, 5 SPS

End-of-run message
STBD STERN QUARTER ,TI 18100
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```
M/V S J CORT FALL '81 TRIALS
        RUN           47          POINT          27
        DATE    09-DEC-81         TIME     09147144
        DURATION OF RUN IN MINUTES IS           0.167
        NORTH LATITUDE (DD MM)          45  5
        WEST LONGITUDE (DD MM)          86 42
        VESSEL'S SPEED (MPH - XX.X)    14.1
        VESSEL'S HEADING (DEGREES)     205
        VESSEL'S DRAFT (FEET)            27
        WIND DIRECTION (DEGREES)          0
        WIND SPEED (KNOTS)               20
        WAVE DIRECTION (DEGREES)          0
        WAVE HEIGHT (FEET)                5
REMARKS
DNBND MICHIGAN, DRAFTS 23 8, 26 10, 26 2
SL 7 AND SL 7 H ACC OUT, 5 SPS

End-of-run message
10 SEC RUN TO AVOID VOLTAGE SPIKE
```

```
M/V S J CORT FALL '81 TRIALS
        RUN           48          POINT          29
        DATE    09-DEC-81         TIME     10127145
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)          41 44
        WEST LONGITUDE (DD MM)          87  6
        VESSEL'S SPEED (MPH - XX.X)     5.5
        VESSEL'S HEADING (DEGREES)     341
        VESSEL'S DRAFT (FEET)            27
        WIND DIRECTION (DEGREES)        330
        WIND SPEED (KNOTS)               29
        WAVE DIRECTION (DEGREES)        330
        WAVE HEIGHT (FEET)                8
REMARKS
OUTSIDE BURNS HARBOR
SL 7 AND SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SEAS TI 10154
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```
M/V S J CORT FALL '81 TRIALS
        RUN           49          POINT          31
        DATE    09-DEC-81         TIME     10131128
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)          41 47
        WEST LONGITUDE (DD MM)          87  8
        VESSEL'S SPEED (MPH - XX.X)     5.5
        VESSEL'S HEADING (DEGREES)     341
        VESSEL'S DRAFT (FEET)            27
        WIND DIRECTION (DEGREES)        330
        WIND SPEED (KNOTS)               29
        WAVE DIRECTION (DEGREES)        330
        WAVE HEIGHT (FEET)                8
REMARKS
OUTSIDE BURNS HARBOR
SL 7 AND SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SEAS, DRAFTS 25 9, 26 6, 26 3, TI 11122
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```
M/V S J CORT FALL '81 TRIALS
        RUN           50          POINT          33
        DATE    09-DEC-81         TIME     10158139
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)          41 52
        WEST LONGITUDE (DD MM)          87 10
        VESSEL'S SPEED (MPH - XX.X)     9.2
        VESSEL'S HEADING (DEGREES)     340
        VESSEL'S DRAFT (FEET)            27
        WIND DIRECTION (DEGREES)        325
        WIND SPEED (KNOTS)               25
        WAVE DIRECTION (DEGREES)        325
        WAVE HEIGHT (FEET)                8
REMARKS
OUTSIDE BURNS HARBOR
SL 7 AND SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SEAS , DRAFTS 25 1 ,26 7, 26 3, TI 12114
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```
M/V S J CORT FALL '81 TRIALS
        RUN           51          POINT          35
        DATE    09-DEC-81         TIM        109101
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)          41 57
        WEST LONGITUDE (DD MM)          87 13
        VESSEL'S SPEED (MPH - XX.X)     8.8
        VESSEL'S HEADING (DEGREES)     340
        VESSEL'S DRAFT (FEET)            27
        WIND DIRECTION (DEGREES)        330
        WIND SPEED (KNOTS)               28
        WAVE DIRECTION (DEGREES)        330
        WAVE HEIGHT (FEET)                8
REMARKS
OUTSIDE BURNS HARBOR
SL 7 AND SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SEAS TI 12150, DRAFTS 25 1, 26 7, 26 3
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```
M/V S J CORT FALL '81 TRIALS
        RUN                52                     POINT        37
        DATE    09-DEC-81                         TIME   11140146
        DURATION OF RUN IN MINUTES IS                      25.000
        NORTH LATITUDE (DD MM)                    42  3
        WEST LONGITUDE (DD MM)                    87 15
        VESSEL'S SPEED (MPH - XX.X)               5.1
        VESSEL'S HEADING (DEGREES)                340
        VESSEL'S DRAFT (FEET)                        27
        WIND DIRECTION (DEGREES)                  327
        WIND SPEED (KNOTS)                           28
        WAVE DIRECTION (DEGREES)                  327
        WAVE HEIGHT (FEET)                            6
REMARKS
OUTSIDE BURNS HARBOR
SL 7 AND SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SAES ,DRAFTS 25 8, 26 6, 26 1, SPD 4.7 MPH,TI 13147
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```
M/V S J CORT FALL '81 TRIALS
        RUN                53                     POINT        39
        DATE    09-DEC-81                         TIME   11147120
        DURATION OF RUN IN MINUTES IS                      25.000
        NORTH LATITUDE (DD MM)                    42  5
        WEST LONGITUDE (DD MM)                    87 16
        VESSEL'S SPEED (MPH - XX.X)               4.7
        VESSEL'S HEADING (DEGREES)                340
        VESSEL'S DRAFT (FEET)                        27
        WIND DIRECTION (DEGREES)                  327
        WIND SPEED (KNOTS)                           28
        WAVE DIRECTION (DEGREES)                  327
        WAVE HEIGHT (FEET)                            6
REMARKS
OUTSIDE BURNS HARBOR
SL 7 AND SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SEAS TI 14117
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```
M/V S J CORT FALL '81 TRIALS
        RUN                54                     POINT        41
        DATE    09-DEC-81                         TIME   11155144
        DURATION OF RUN IN MINUTES IS                      25.000
        NORTH LATITUDE (DD MM)                    42  6
        WEST LONGITUDE (DD MM)                    87 17
        VESSEL'S SPEED (MPH - XX.X)               4.5
        VESSEL'S HEADING (DEGREES)                346
        VESSEL'S DRAFT (FEET)                        27
        WIND DIRECTION (DEGREES)                  320
        WIND SPEED (KNOTS)                           26
        WAVE DIRECTION (DEGREES)                  350
        WAVE HEIGHT (FEET)                            8
REMARKS
OUTSIDE BURNS HARBOR
SL 7 AND SL 7 H ACC OUT, 5 SPS

End-of-run message
HEAD SEAS TI 14147
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```
M/V S J CORT FALL '81 TRIALS
        RUN                55                     POINT        43
        DATE    09-DEC-81                         TIME   12133126
        DURATION OF RUN IN MINUTES IS                      25.000
        NORTH LATITUDE (DD MM)                    42  6
        WEST LONGITUDE (DD MM)                    87 17
        VESSEL'S SPEED (MPH - XX.X)               14.2
        VESSEL'S HEADING (DEGREES)                165
        VESSEL'S DRAFT (FEET)                        27
        WIND DIRECTION (DEGREES)                  318
        WIND SPEED (KNOTS)                           26
        WAVE DIRECTION (DEGREES)                  300
        WAVE HEIGHT (FEET)                            6
REMARKS
OUTSIDE BURNS HARBOR
SL 7 AND SL 7 H ACC OUT, 5 SPS

End-of-run message
STBD STERN QUARTER TI 15155
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```
M/V S J CORT FALL '81 TRIALS
        RUN                56                     POINT        45
        DATE    09-DEC-81                         TIME   21119100
        DURATION OF RUN IN MINUTES IS                       0.250
        NORTH LATITUDE (DD MM)                    42  6
        WEST LONGITUDE (DD MM)                    87 17
        VESSEL'S SPEED (MPH - XX.X)               14.2
        VESSEL'S HEADING (DEGREES)                165
        VESSEL'S DRAFT (FEET)                        27
        WIND DIRECTION (DEGREES)                  318
        WIND SPEED (KNOTS)                           26
        WAVE DIRECTION (DEGREES)                  300
        WAVE HEIGHT (FEET)                            6
REMARKS
VOLTAGE CALS
SL 7 AND SL 7 H ACC OUT, 5 SPS

End-of-run message
NO GOOD
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```
M/V S J CORT FALL '81 TRIALS
        RUN                57                     POINT        47
        DATE    09-DEC-81                         TIME   21120110
        DURATION OF RUN IN MINUTES IS                       0.250
        NORTH LATITUDE (DD MM)                    42  6
        WEST LONGITUDE (DD MM)                    87 17
        VESSEL'S SPEED (MPH - XX.X)               14.2
        VESSEL'S HEADING (DEGREES)                165
        VESSEL'S DRAFT (FEET)                        27
        WIND DIRECTION (DEGREES)                  318
        WIND SPEED (KNOTS)                           26
        WAVE DIRECTION (DEGREES)                  300
        WAVE HEIGHT (FEET)                            6
REMARKS
VOLTAGE CALS
SL 7 AND SL 7 H ACC OUT, 5 SPS

End-of-run message
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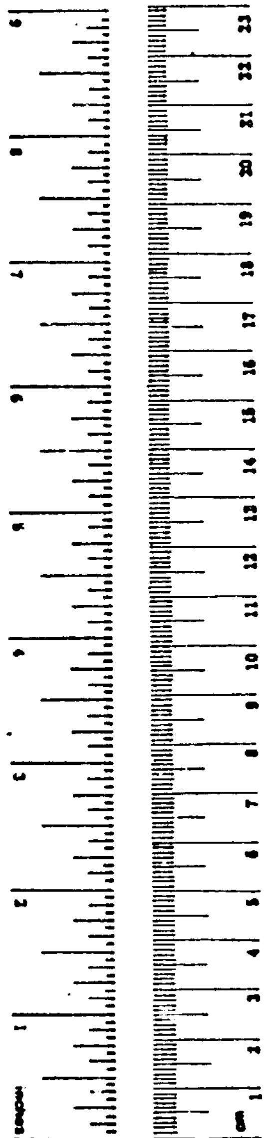
END TAPE 2

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F